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THE INDUSTRIES OF NORTH WALES.

Nantlle Slate Quarries.

THE Dorothea Quarry is situated in the centre of the Nantlle Valley, and is one of the most important in the district. The cleavage in the quarry is almost vertical, following the rule we have before stated. The quarry consists of four different pits or sink-quarries. The pits have now grown to an immense size. Their principal riches consist of the purple vein, which this quarry possesses in very great thickness. The red vein which passes through the property loses much of its value through the absence of foot joints. The pits are being worked downwards in ledges or galleries. Some of them are slung all day over the brink by a rope, a most perilous occupation, as loose rock from above very often falls down upon them. It may also be remarked that very many of the accidents which occur are caused mainly through the men's own carelessness. They become so accustomed to danger that it requires the greatest attention on the part of the agents to keep the men from rashly exposing their lives. The rubbish heaps of this quarry are seriously filling up all the available space. The huts in which the men dress and split the slates are ranged in rows along these banks, while a small locomotive passes along the lines, taking up the slates and delivering the rough blocks. The quarry is the property of a number of private gentlemen, of whom Mr. Williams, Glanbeuno, Carnarvonshire, is the principal representative. The quarry manager is Mr. John J. Evans. The number of men employed varies from four hundred and fifty to five hundred.

Cilgwyn Quarry is the oldest quarrying enterprise in Nantlle, and possibly in North Wales. It is situated on the northern slopes of the valley. It was not until the present century that the operations were carried on here with anything like activity. The present company, the principal representative of whom is William Hayward, Esq., of Carnarvon, have been in possession for twenty-four years, and during the whole of that time the quarry has been under the superintendence of Mr. Ellis Williams. There are four separate pits belonging to the quarry.

The principal riches of this quarry have been the Faengoch, the red or purple vein which is known throughout its course as Faengoch Cilgwyn. The descent into the principal pit from whence this vein is excavated can be made by a small car which travels along two steel girders. Once at the bottom, it will be observed that it is covered by a huge fall of trap-rock. The great fall took place three years ago, and since that time the workmen have been constantly engaged in removing it. The descent of the slate vein, as before explained, is into the centre of the mountain; and this huge mass of trap-rock lay on the northernly side of the pit, overhanging considerably. Ere it fell there were potent signs of the event. Loud cracks, much like reports of a gun, were heard continually. Everything was prepared, and the tramway which lay upon the floor of the pit removed. Luckily the mass gave way upon a Sunday evening, so that no one was in any way injured by it. The circumstance has very greatly crippled the resources of the quarry, but its entire removal is now quickly approaching. This pit is now one hundred and twenty yards deep.

A peculiarity concerning the red spotted vein in this quarry is that it widens as it deepens. At the present depth of the quarry it is sixty yards wide. The oldest pit, called the Old Cilgwyn Quarry, is not being worked, owing to a great fall of rock from the northernly side, which has completely filled the excavations. At a future period this will no doubt be cleared out and worked with profit. The pit known as Cloddfa'r Clytiau is being worked very busily. The most profitable portion of the quarry is the northern, where the foot-joints are remarkably regular; the rock is thus very economic to quarry. The slate is here of a reddish hue. Immediately adjoining it is a hard purple rock, and further on a blue vein, through which there runs a remarkable oblique dyke of greenstone, regularly interspersed with white spar.

Pen-y-Bryn Quarry is situated to the north of Dorothea Quarry. It is an old speculation, and was formerly worked by Turner and Casson, two of the principal names connected with the development of the slate quarries in North Wales. It consists of four pits. All of them are more or less encumbered with rubbish, the result of successive falls, and requiring considerable attention at the hands of the manager. The slate is of a desirable purple and blue colour. There also runs between these veins, and to a certain extent through them, a thin seam of green slate, known as the green slate dyke. Mr. W. Davis is the manager of the quarry, which is owned by a private company.

The Talysarn Slate Quarry is another quarry busily engaged in removing a large quantity of worthless rubbish which they received as a heirloom along with the quarry. It is generally supposed that when this has been effected the present active management will be able to turn the resources of the quarry into good account. The managing director of the company is Mr. Robinson.

The Braich Slate Quarry is situated upon the brow of the long hill lying upon the northernly side of the Nantlle Valley, and known as the Cilgwyn mountain. It consists of one large pit worked in three floors, in which the principal vein is the Faengoch, similar to that found in the Cilgwyn Quarry. In that portion of the quarry already opened the chief deficiency is in joints. The rock is one great solid mass, requiring a very considerable amount of labour to break up. But there is a "slant" running through the quarry at a certain depth, below which the nature of the slate rock is altered for the better. The agent is Mr. R. P. Williams, and the owners a private company.

The Pen-yr-Orsedd Quarry is an undertaking of considerable importance. Under the superintendence of Mr. Darbishire, of Nantlle, the managing directors have opened a new pit upon the property, which has been found to produce slates of a much superior character to those in the old undertaking. The Iron Quarry is situated upon the easternly extremity of the vein. It has suffered considerably from the presence of water, but is now being worked with some energy. The Voel Quarry supplies slabs principally, and is in the immediate proximity to the last-mentioned quarries. The Alexandra Quarry is commencing operations upon the red vein after having been for a long time engaged upon the construction of a tunnel through a thickness of greenstone. Galltyfedw Quarry is situated at the bottom of the valley. It is an old work, and has already yielded a large quantity of good slates. Since then it has been flooded, but one of the pits has now been cleared, and is being worked. R. D. Williams, Esq., of Carnarvon, is the principal proprietor. Cloddfa'r Coed Quarry is another which has been obliged to succumb to the constant stream of water which poured into the quarry. Upon the southern side of the valley the principal quarries are Tan'rallt and Fronheulog quarries, both of which produce good slates.

Llanfihangel-y-Pennant.

This is a valley running from the range of hills which shut the southern side of the Nantlle Vale towards the sea at Criccieth on the shores of the Cardigan Bay. The slate vein crosses the valley obliquely, and is or has been worked on the hills on either side of it. Upon the westernly side, near the entrance to the valley, is the Hendre-ddu, or Prince Llewelyn Quarry. It is an old venture lately re-opened by a private company, and under the managership of Mr. Thomas Evans. The situation of operations has been removed a little more to the eastward, where the vein appears more profitable. The fault with the old slate was the presence of ribs which ran across the slate, the slate being liable to break in such places, and it is anticipated that the new trial will prove to be free from that fault. Further north is the Moelfra Quarry, standing upon the same vein, which, though not very extensive, is being worked spiritedly. At the head of the valley is a small quarry called the Pennant Vale, or Dolgarth Quarry. At the easternly side of the entrance is Isallt Quarry, once carried on very flourishingly, but since for many years idle. At the head of the valley, and upon the easternly side, is the Prince of Wales Quarry, owned by a limited liability company, of whom Thomas Harvey, Esq., is the general manager, and Mr. John Roberts, the superintendent. The quarry is situated upon the side of the hill, and comprises seven galleries. There are two shades of slate in the quarry, both being grey blue of more or less intensity. The veins are upwards of two hundred yards wide, and bounded by greenstone on either side. Near the entrance to the Pennant Valley, a little more easterly, and at the foot of a high mountain called Moel Hebog, is the now abandoned slate quarry known as Gorseddau, once one of the most active in North Wales. No expense was spared in opening out the quarry. A very costly tramway was made to Portmadoc, distant about six miles. A gigantic machine room was constructed supplied with a large number of sawing, planing and dressing machines. Everything went on swimmingly for a short time, when it was found out that the slate vein had been much over-valued, and operations were stopped immediately. This property, we understand, has passed into the possession of the proprietors of the Prince of Wales Quarry. They propose utilizing the tramway by narrowing the gauge from three feet to two, and carrying it on to their own quarry, a distance of four miles. This will be a great advantage to them, and, indeed, to the district. The present cost of transporting goods by cart retards the development of the district seriously.

Mr. Samuel Holland, M.P., whose portrait we give with this paper, is a naturalized Welshman. His father was an English gentleman, who came to Merionethshire when slate quarrying was in its infancy. He made his home in Festiniog, and his son Samuel, from a very early age, became accustomed to slate quarrying. The Hollands, *père et fils*, commenced the Welsh Slate Company's Quarry, but, as is noted in our sketch of the quarry, sold the valuable property. To a great extent he is the architect of his own fortunes. He is a man universally respected, and occupies many important positions in the county. He is the Constable of Harlech Castle. He has been for many years a justice of the peace for the county of Carnarvon, and holds a similar position in the county of Merioneth. He is chairman of the magistrates meeting at Penrhyndendraeth, and for more than fifteen years has been a chairman of the board of guardians of the Festiniog Union. He has always identified himself with the public requirements of North Wales, and more especially with his adopted county. In politics he is a Liberal, and now represents the county in Parliament in that interest. Previous to the election of the late Mr. David Williams, of Castell Dendraeth, in 1868, the county, since it was first represented, was always considered a pocket-borough of the Wynnes of Peniarth. In 1859, Mr. Holland and other leaders of the Liberal party, induced Mr. D. Williams to contest the representation. The struggle throughout North Wales was considered a forlorn hope. Contrary to all expectations, he was only defeated by a narrow majority. In 1865 another attempt was made, resulting in a defeat by an equally narrow majority. In 1869 Mr. Holland struggled hard, and succeeded in unseating Mr. W. R. M. Wynne, by a majority of 600 votes, for Mr. D. Williams. This gentleman only voted once in Parliament, upon the second reading of the Irish Church Act, his death following soon after. Mr. Holland was then put forward as a candidate, and was opposed in the Conservative interest by Colonel Tottenham. But Mr. Holland's candidature was so successful that his opponent thought fit to withdraw a fortnight before the polling day. Mr Holland is a very popular representative.

Bethesda.

The chief fame of this district lies in the Penrhyn Quarries, which are upon the opposite side of the Elidir Mountains to those of Llanberis. As the vein proceeds onwards to the sea at Aber, there are three other quarries—Pant Dreiniog, Tanybwlch, and Bryn Hafod y Wern quarries. This is the extremity of the slate vein. The village of Bethesda is five miles from Bangor. The

whole district of Llanllechid is a populous one, and it is a matter of surprise to every stranger that there is no railway connection. There is a tramway leading from the quarry, but this is confined exclusively to the use of the quarry. It is said that persons in power in the neighbourhood think that the construction of a railway would do them more personal harm than it would the public good. Bethesda is in the neighbourhood of high mountains. Carnedd Dafydd and Carnedd Llewelyn, two of the highest mountains in North Wales, rise from the easternly side of Nant Francon, the little vale in which the river Ogwen takes its source; while opposite to them are the Fronllwyd, Benglog, and in the distance the lesser Gludar. Bethesda consists of a long straggling mass of houses, built upon the easternly slopes of the valley of the Ogwen. A stranger would notice at once the great number of dissenting chapels. There are seven or eight of them within a very close proximity to each other.

The Penrhyn Quarries, situated upon the northernly side of the Fronllwyd mountain, have been noted for their riches even so far back as three centuries ago. Not to say that there was anything approaching a brisk slate trade being carried on at that time. At the beginning of the present century, there were 150 men engaged in the quarry. It is stated that the foreign war which raged at this time greatly crippled the quarrying operations, as a war-tax was imposed upon all exportations; but it soon recovered its position. The present owner, Lord Penrhyn, came into possession through marrying the heiress to the estate; he was then the Honourable Edward Gordon Douglas, and adopted the name of Pennant. He was created a peer in 1866, by the Disraeli Government, under the style of Baron Penrhyn, of Penrhyn. The success of this quarry has been due in a great measure to the enlightened system of operations carried on by the head manager, Mr. William Francis, who has been engaged in it since the year 1826. He first commenced making one grand work, instead of a dozen or more separate operations; the mountain now being quarried in the shape of a wedge. As in Llanberis, the mountain is excavated in galleries, the waste being carried along either wing and deposited upon useless ground on either side. Upon the lower galleries there are ranges of huts for the slate makers, and there is also a large foundry where the blocks are sawn and planed into slabs. From the centre of the quarries, there rise large upright masses of waste rocks, which hitherto it has not been considered necessary or profitable to remove. Standing in the vicinity of these rocks, the plan of the whole quarry can be very easily comprehended; the mind is impressed with the vastness of the excavations, more especially when one of the galleries is approached and found to be a step at least a score of yards in height, and not, as those in the distance would appear, a few feet. The distance from one end of the galleries to the opposite end of the wing, is about a mile; the lowest galleries in the quarry are below the level of the surrounding ground, and the *débris* has to be hoisted from them by means of huge water balances; there are six of these. The workshops where the slates are dressed are very extensive; the whole quarry gives work to about 2,800 men. The rotation of veins in this quarry is as follows:—First, the green vein, which is very little worked; then the glâs rhywiog, or royal blue; then the bastard rhywiog, a grey slate with darker markings; bastard caled, somewhat harder and supplying second-class slates; glâs rhywiog, the best slate in the quarry; faengôch, a layer of whinstone; and lastly, the glâs caled.

The Pantdreiniog Quarry is the nearest to the Penrhyn Quarries, upon the north-easternly side of the River Ogwen. It is owned by a company calling themselves the Bangor and Pantdreiniog Slate Company, Limited. The veins here are more to the north-west than those in Lord Penrhyn's quarries. They are identical with those in Glynrhonwy Quarry, Llanberis. There are three descriptions of slates in this property, blue, red, and green; but only the two former are now being worked. The bottom of the quarry is covered with water, and has been so for some time. Arrangements are being made to clear this away, and extend the working of the quarry. The blue vein is now being opened out towards the south-east.

Proceeding in the same direction the next quarry we meet is the Tanybwlch Quarry, the property of the Port Bangor Slate Company, Limited; Mr. G. S. Tolson is the managing director. The vein passing through the quarry is the blue-mottled. This is an old venture, but the old pit is being now abandoned and a new quarry opened upon another portion of the property. In the old pit the rocks are split up into very small fragments by faults which pass through the quarry.

Bryn Hafod-y-wern Quarry dates back to a very remote period, and is the furthest quarry in this direction. It is owned by a limited company, of which Mr. G. W. Cooke is the managing director. Blue and green slates are obtained at the quarry, the former being partially mottled.

Festiniog.

The village of Festiniog proper is not the centre of the slate quarrying district. It is situated at one of the horns of a crescent which extends for a distance of six miles, and is more or less populated along the whole line. The principal point on the line is the village of Fourcrosses. Between Fourcrosses and Festiniog is a point known as Congl-y-wal, and from the former place to the opposite extremity of the slate colony are the villages of Rhiwbryfdir and Tan-y-grisiau. The district is situated at the head of the Maentwrog valley, and lies about eighteen miles from Portmadoc. It is now reached by a narrow-gauge railway from that place. This dwarf railroad excites the wonder of all visitors. It runs along the sides of the Moelwyn mountain. The gauge is 2 ft. and the results obtained on this line have since been made use of in many parts of Europe. Many of the gradients along the line are extremely steep, and present obstacles which old engineers would have been entirely unable to overcome. The short journey, with the novelty of the little carriages and the dwarf double engines, and curious sensation of travelling along a very narrow ledge of the mountain steep, is one full of romance. The late Mr. Spooner, of Portmadoc, surveyed the distance and made a tramway for horse traffic. He also tried a great number of experiments on the line, and became firmly of the belief that an engine could be constructed to do the work. His son, Mr. C. E. Spooner, followed up these speculations; and after preparing elaborate plans, a young engineer, Mr. C. M. Holland, nephew to Mr. Samuel Holland, M. P., invented a small locomotive, which was found to answer the purpose admirably. There are two new railways now being constructed. One is by the London and North-Western Railway Company through the Rhiwbryfdir valley to connect with the Bettws-y-Coed railway. This will bring out Conway as a slate port. The other new line belongs to the Great Western Railway Company, and will utilize the line already existing between Fourcrosses and Festiniog village, and will proceed through Trawsfynydd to Bala, and will be an expeditious route to the midland counties. These two new railways will doubtless reduce the trade of Portmadoc considerably. The Portmadoc and Festiniog railway having been hitherto the only line from the quarries, Portmadoc has had a monopoly of the trade.

The quarries in the Festiniog district are situated as follows. Ascending the slopes of the Moelwyn from Portmadoc we have first of all the Croesor Quarry, then at some distance Rhosydd Quarry. The latter is situated on the side of the Moelwyn mountains, within a narrow gorge formed by those mountains and the Cnicht mountain. At this point the gorge turns towards the south, and we come across a small lake known as Llyn Cwmorthin. It is enclosed by the Moelwyn and Rhiwbryfdir mountains. Rising from this lake is the Cromorthin Quarry. Upon the opposite slopes of the Rhiwbryfdir mountain are Holland's Quarry, Rhiwbryfdir or Middle Quarry, and the Welsh Slate Company's Quarries. These are upon one side of the Rhiwbryfdir valley through which the London and North-Western railway is about to be constructed. Upon the opposite side of the valley is the Llechwedd Quarry, upon the slopes of the Carregdu a rock which divides the Rhiwbryfdir valley from a similar gorge, at the foot of which lies the village of Festiniog. Proceeding over the hill from the Llechwedd Quarry, we have the Volty and Bowydd or Lord Quarry, then the Maenofferen Quarry, and the Diphwys-Casson Quarry. This latter is situate upon the rock called Diphwys. Further towards Festiniog village is the Manod mountain, not far from the top of which is the Craig-ddu Quarry, and upon the opposite side of it the Bwlch Slaters' Quarry. Descending the sides of the Manod we come to a straggling mountain range known collectively by the name of Mynydd Migneint, and upon it we have the Drum and the Voelgron Quarries. Starting again at the village of Fourcrosses and ascending the valley upon the ridge, is the Cwt-y-bugail Quarry; and upon the slopes leading down to the village of Penmachno is the Rhiwbach Quarry, Blaen-y-Cwm Quarry and the Rhiw Fachno Quarry. Again proceeding from Rhiwbryfdir towards Dolyddelen we have a new quarry of some pretensions being opened, called after its proprietor (Mr. O. Gethin Jones) the Gethin Quarry. Upon either side of the Dolyddelen valley are the Prince Llewelyn or Bwlch Quarry, and the Rhiwgoch Quarry, and the Vedw and Penllyn Quarries. The village of Fourcrosses is 700 ft. above the sea level. It is a rapidly improving neighbourhood, containing a large number of public schools, a hard-working school board, and a large number of places of worship, principally belonging to the dissenters.

The Welsh Slate Company's Quarry is the largest in the district, and dates back to the beginning of this century. Mr. Oakeley, the landowner, first commenced the work, but gave up to Mr. Samuel Holland and his father, who came in the year

1819 from Liverpool. They, by careful and intelligent management, succeeded in making it a profitable investment, selling it while in a very flourishing condition to a company of London gentlemen, amongst whom was the late Lord Palmerston. The company style themselves the Welsh Slate Company; Mr. G. Christopher Chissel being the manager, and Mr. Robert Owner the agent. This quarry, like most of the Festiniog quarries, is worked underground, by means of chambers cut into the slate vein, alternating with pillars of the rock left to support the roof. The slate vein, as before stated, descends obliquely into the ground. The veins are first of all the "top vein," seldom worth quarrying; next is the "barred vein," the upper part of which is usually profitless; below this is the "old vein," the most profitable, and the one which composes the chief riches of this quarry. The floor of this vein is a layer of whinstone, called the "lower hard," and above it is a clean regular slant, called the "clay slant," which, except where there are faults, always forms a good roof. Below the "lower hard" is the new vein now being worked in the Diphwys Quarry; this has only lately been discovered; a chamber is about sixty yards high (the thickness of the vein), and about twenty yards wide. These chambers descend at an angle of about thirty degrees for three or four floors. A few of the first chambers are open to the sky, but as they proceed into the mountain they are entirely underground. There are bridges across these chambers at various depths, with tunnels through the pillars of slate, which are left to support the mass of rock overhead, and which are almost as broad as the chambers. The rock and rubbish are all brought to one place, and there hoisted by means of a water balance to a huge mill on the top of the hill.

BELLS, BELL METAL, AND BELL FOUNDING.

AMONG articles of metal manufacture *Bells* occupy an interesting place, on account alike of the nature of the alloy employed in their production, the shape and proportions best fitted for the emission of resonant sounds, and the literature with which they are associated. That bells were of very early origin we have abundant proof. Small golden bells, we are told, were worn as ornaments on the hem of the priest's robe in Mosaic times; they were worn in the same manner by the kings of ancient Persia. In Egypt, the feast of Osiris was announced by the sound of bells. Hand bells were used in the Greek camps and garrisons, to test the vigilance of the sentinels, and also in the fish markets. Among the Romans, bells were used to denote the hour of bathing and the opening of the markets; to hang to the necks of cattle and sheep; and to decorate triumphal chariots. On the break-up of the Roman Empire, Constantinople in the east, and Rome in the west, were the means of perpetuating the use of bells.

Small bells, to be held in the hand, were prior in use to those large enough to be hung in towers and belfries. At the present day, Birmingham is the chief centre of this branch of the trade in England. The founders are said to adopt a certain ratio of height, width, and thickness for each class of bell—more, perhaps, as a matter of habit or custom than for real acoustic reasons. The postman's bell and the dustman's bell have gone nearly out of use; but we retain still the muffin bell, the street door bell, the room bell, the office bell, the railway bell, the dock bell, the ship bell, the ostler's bell, the prompter's bell, the sheep bell, and many other varieties. Some of the table bells used in well-furnished apartments are beautiful articles of manufacture in acoustic action and in ornamental character. Mr. Timmins, in his interesting account of the manufacturing industries of Birmingham, states that the bell-founders of that busy town sometimes execute orders which English people generally little surmise:—Messrs. Scholefield, Son, and Goodman not long since executed an order for ten thousand green bronzed and lacquered house-bells, twelve ounces in weight each, for a West African prince, to adorn his new iron palace. Messrs. J. Wilson and Co. also recently received an order from another African prince for a number of polished ship bells in elegant frames, and mounted on mahogany stands, some of which were engraved with the name assumed by the distinguished potentate, "Yellow Duke, Esq."

Church and Turret Bells.

Greater importance, of course, is to be attached to the larger bells intended for church use. Large bells, so far as can at present be ascertained, were first used in churches by Paulinus, Bishop of Nola, about A.D. 400; they were made in the Campagna or Campania—whence the terms *campana*, *campanile*, *campanology*. They were introduced into France a century or two later, and into England by some of the early missionaries. The Abbot of Wearmouth brought one from Italy for his church in 680. Croyland Abbey had a large bell in 870, and soon afterwards six smaller bells were added to it to form a peal. Pope John XIII. in 968 consecrated a large new bell in the Lateran Church, baptizing it by the name of John. Bells were not made in Germany or Switzerland so early as in Western Europe. It was considered a memorable event in the eleventh century when a bell of 1 ton weight was presented to the city of Orleans. A century or two later many of larger dimensions were founded. One, that was baptized "Jacqueline," cast at Paris in 1400, weighed more than 6 tons; another Paris bell, dated 1472, weighed over 10 tons; while the famous bell of Rouen, cast in 1501, was but little short of 16 tons. Our English great bell of St. Paul's, "Great Tom of Oxford," "Great Tom of Lincoln," and "Great Peter of York," do not approach near the Rouen bell in magnitude. Other bells of much notoriety are those of Dantzic, 6 tons; Halberstadt, 7¼ tons; Mechlin, 9 tons; Görlitz, 10¾ tons; Breslau, 11 tons; and Olmütz, 18 tons. Mr. E. B. Denison, a few years ago, gave the following table of the weights and dimensions of twenty-two large bells; the numbers in some instances do not quite agree with those presented by other authorities. Of the mighty bells in Russia and China, and of "Big Ben" at Westminster, we shall have to speak more in detail presently:—

	Weight. *Tons.*	Diameter. *Feet.*	Thickness. *Inches.*
Moscow	193	21	23
"	63	—	—
Pekin	53	—	—
Novgorod	31	—	—
Vienna (1711)	17¾	9·0	—
Sens	15	8·6	—
Westminster	14	9·2	9
Erfurt (1497)	13¾	8·6	—
Notre Dame	12¾	8·6	7¼
Montreal (1847)	12¼	8·6	8¼
Cologne	11¼	—	—
York (1845)	10¾	8·3	8
Bruges	10¼	—	—
St. Peter's, Rome	8	—	—
Oxford (1680)	7½	7·1	6⅛
Antwerp	7¼	—	—
Exeter (1675)	5¾	6·3	5
Lincoln (1834)	5¼	6·8	6
St. Paul's (1709)	5¼	6·7	—
Ghent	5	—	—
Boulogne	5	—	—
Lincoln (1610)	4½	6·3	—

Bell sounds, and consequently the names of bells, have been much diversified according to the uses to which they were applied. The *couvre-feu* or *curfew* bell, rung as a signal to extinguish the wood fires of the olden days, were common in England, Scotland, France, Italy, and Spain. Eight o'clock evening ringing is still common in some parts of our island. The *passing bell* was tolled when a person was dying; the present occasional custom of tolling *after* death is a relic of this, with the real meaning obliterated. The *sanctus*, or *saint's bell* was rung when the priest came to a particular part in the service of the mass, to give notice to the faithful in and near the church, to fall on their knees. The *pardon* or *ave* bell was tolled before and after service—first to call the worshippers to a preparatory prayer to the Virgin, and then as an invocation at the end of the service. When the old faith was giving way to the new in England, the Bishop of Sarum in 1538 issued an order, "That the bell called the Pardon or Ave bell, which of longe tyme hathe been used to be tolled three tymes after and before divine service, be not hereafter in any part of my diocese any more tollyd." In olden days church bells were regarded with a pious reverence which we can but imperfectly realize now. It was considered orthodox to name a bell after the patron saint of the church in which it was used. If there were two or more bells, and two or more chapels, shrines, or altars within the church, the largest was named after the patron saint of the church itself, and the smaller after the saints to whom the included sanctuaries were dedicated. Occasionally the bells recorded by their names some of the attributes of the patron saint, or some incident in his life.

The Giant Bells of Russia and China.

Russia, as already implied, is the birthplace of the largest bells ever founded. The *Czar Kolokol*, or emperor of bells, at Moscow, approaches nearly 200 tons in weight, something like

400,000 lbs. English, and contains enough metal for thirty such bells as ours at St. Paul's. A bell cast at Moscow in 1654 was greatly damaged by fire in 1701; after remaining useless for a whole generation, it was remelted by order of the Empress Anne, who gave an additional 72,000 lbs. of metal; Michael Motorine superintended the refounding in 1734, and thus the Czar Kolokol came into existence. The Muscovite nobles are said to have vied one with another in throwing into the melting furnace costly articles of gold and silver, such as plate, rings, and ornaments. The bell was suspended at a small height above the floor of the casting pit; but three years afterwards, in 1737, a fire destroyed the immense beams from which it was suspended; the huge mass came down with a crash, and a piece was broken out of the side of the bell "large enough to admit two tall men to walk abreast through the gap without stooping." The bell, ornamented on the exterior with elaborate bas-reliefs of sacred and imperial personages, remained useless a whole century. In 1837, Montferand, a French engineer, undertook to raise it. The ground was cleared away around the bell, and a strong scaffolding erected over it. Six hundred soldiers applied their strength to a number of capstans, and in less than an hour the bell was raised to a sufficient height to permit a massive platform of timber to be built beneath it. The next operation was to lower the platform on a sledge, and drag it up an inclined plane to a pedestal prepared to receive it. The Czar Kolokol was there deposited as a national memento, not for use as a bell, but to form the domed roof of a little chapel. The gap in the side still exists.

The largest bell actually in use in Russia is the *Novo Kolokol*, or new bell, at Moscow. A history somewhat like that of the Czar Kolokol attaches to it. A majestic bell of sixty-three tons, called the *Bolshoi*, was cast in 1710, and hung, with thirty-two smaller bells, in the belfry of the Ivanovskaya Kolokaluya. A little over a century afterwards, during the burning of Moscow consequent on the French invasion, the belfry was destroyed, and the bell irreparably injured. The Emperor ordered the damaged bell to be broken up in 1817, and presented additional metal to increase the weight to seventy-two tons. The refounding was conducted by M. Bogdanov, in the presence of an august assemblage, who threw gold and silver into the melting furnace. In 1819, the bell was moved on a sledge from the foundry to the cathedral, the people vieing one with another for the honour of dragging at the ropes. When the bell was in its destined place the populace kissed the hands, the feet, the garments of M. Bogdanov, in gratitude for its resuscitation. Some days afterwards the bell was slowly raised into its place. This noble bell, the largest ever suspended in a belfry, is 21 feet in height by 18 feet in diameter. Its sound is said to "vibrate all over Moscow like the fullest and lowest tones of a vast organ, or the rolling of distant thunder." A great bell fell at Moscow in 1855, but we do not know whether it was the Novo Kolokol.

The country which approaches nearest to Russia in the size of its bells is China. The Emperor Yung-lu about the year 1405 transferred the seat of government from Nankin to Pekin, and celebrated the event by casting nine bells of great magnitude. They were not known to Europeans until about the middle of the seventeenth century, when Father Verbiest saw seven of them lying on the ground. He measured one of them; the English equivalents denote 14½ feet high, 13 feet diameter, 13 inches thick. Le Comte saw four large bells lying on the ground at Nankin at the end of the same century, among the ruins of a belfry in which they had hung; each was 11¼ English feet high by 7½ diameter, with a weight of 24 tons.

Big Ben of Westminster.

There are several bells in Europe larger than that which soars at the vast height of 200 feet above the ground in the north tower of the New Houses of Parliament; but there are none others so large in England, and none that have had so eventful a history.

When Sir Charles Barry's lavishly-decorated building was in progress he advertised for tenders for a clock worthy of the structure; but it was not until 1859, after a series of negotiations and wranglings bewildering to follow, that the clock was set up in its place. This unequalled clock (for it seems really to deserve the character of being the noblest in the world) was to have had an hour-bell of eight or ten tons weight, and eight smaller bells to chime the quarters. It was afterwards decided that the chime bells should be only four in number, to be placed in the four corners of the bell-room. The largest, 4½ tons, gives the note B; the second, 2 tons, the note E; the third, 1½ tons, the note F♯; and the fourth, 1¼ tons, the note G♯. These bells produce a pleasing musical chime, which is by this time known to most Londoners, and which is thus varied:—At a quarter past every hour they play a phrase of melody of four notes, G♯ F♯ E B; at the half-hour two of four notes each, E G♯ F♯ B, E F♯ G♯ E; at the three-quarters, three of four notes each, G♯ E F♯ B, B F♯ G♯ E, G♯ F♯ E B; while at the hour they ring out the four-phrase tune E G♯ F♯ B, E F♯ G♯ E, G♯ E F♯ B, B F♯ G♯ E.

The great bell was a matter of much more consideration than these chime bells. The suggestions of many advisers led the authorities to decide on larger dimensions than had at first been intended—about fourteen tons weight, eight feet high, nine feet diameter, and nine inches thick at the sound-bow (the part where the hammer strikes). It was to yield a note E, one octave lower than the E quarter bell, so as to harmonize well with the rest; and to be struck with a hammer of a ton weight. This bell was designed by a skilful amateur, Mr. E. B. Denison, and cast by Messrs. Warner at Stockton-on-Tees in 1856. The mould was six weeks in preparation; two furnaces were built of ten tons capacity each, and eighteen tons of molten metal were poured into the mould. When cooled, extricated from the mould, turned, trimmed, toned, and finished, it was brought to London, and placed in a temporary wooden shed at the base of the clock tower. According to custom, a saint's name was given to the bell, *St. Stephen;* but the public soon hit upon something more homely. Sir Benjamin Hall, at that time Chief Commissioner of Works and Public Buildings, had much to do with the clock and bell subject; a random joke in the "Times" suggested the name *Big Ben* for the bell, and Big Ben it has been ever since in popular if not official language. One day, while the bell was being struck, the sound became dull and unmusical; this was found, on examination, to be due to a crack in the metal. Rumours spread that "Big Ben was cracked;" moreover, that any further hammering would shatter it into pieces. The conferences, correspondence, and disputes that ensued were too complicated to be noticed here; suffice it to say that another bell was cast by other founders, Messrs. Mears, of Whitechapel. This second Ben was somewhat less in weight than the first, but yielded the same pitch of sound. After being tested in regard to musical quality by Dr. Turle, organist of Westminster Abbey, it was raised in its place in the clock tower in October, 1858; the bell, cradle, chains, and tackle weighing together twenty-five tons. It may be worth remembering that at six miles distance the sound of this noble bell is heard just about half a minute after its true time—a measure of the velocity of sound through the atmosphere.

The Metal and the Shape of Bells.

The best composition for bell metal has long been matter of controversy. Four parts of copper to one of tin is the ratio adopted by some founders, three to one is preferred by others; some have risen to ten to one, while less definite proportions have also their advocates. Bells cast in the reign of Henry III. have, on analysis, been found to consist of two copper to one of tin. Small bells discovered by Mr. Layard in the palace of Nimroud had ten copper to one of tin. Chinese gongs are believed to have about the same proportions of metal as the large bells of that country. Big Ben has twenty-two copper to seven tin. When Dr. Clarke was in Russia, while the mighty Czar Kolokol was lying broken and useless, he asked permission to assay or analyze a small bit of the metal; this was refused; but when the bell was raised in 1837, by order of Emperor Nicolas, an analysis gave the proportion of six copper to one of tin, with a scarcely appreciable trace of other metals. An opinion has been expressed that an extra proportion of tin improves the sonorous quality of the bell, but at the same time makes the metal more brittle; if this be so, it may account for the diversity of practice among founders, according as they wish to obtain richness of tone or durability.

Silver and gold, as we have said, have been sometimes added to the metal of bells, partly from a feeling of reverence, partly from a belief that the noble metals improve the quality of tone. The trace of these metals found in the great Moscow bell bears too small a ratio to the ponderous mass to be worth recording. It is now believed that anything more than a very small percentage of silver would injure rather than improve the tone. The Russian custom has not been without its imitators in England; for in the casting of a bell for Lavenham Church, the neighbouring gentry, after drinking the toast of "Church and King," threw the silver tankards into the melting furnace. Bells have occasionally been made wholly of silver; but these were usually of small dimensions, such as hand-bells. Benvenuto Cellini made a beautiful silver bell for Pope Clement VII.; it was chased with figures of lizards, grasshoppers, flies, &c., and its sound was intended to drive away those objectionable visitors (one among many old notions presently to be noticed).

Other metals besides those above named are occasionally employed; lead, arsenic, antimony, or zinc being added to the copper and tin. Hand-bells are made of admixtures of two or

more of these metals, as well as of brass and German silver. Steel bells have their admirers, on account of their lightness, cheapness, and sweetness of tone; but the sound is not of long duration, and does not penetrate far. At the International Exhibition of 1862 the Bockum Mining and Cast Steel Manufacturing Company displayed a cast steel bell of very large size; and founders at Sheffield, Dundyvan, Dublin, and other towns have made peals of steel bells; but the practice is not making much progress. A mixture of iron and tin has been found too brittle. Glass bells are occasionally made, but the material is ill-fitted to bear the blows of a hammer or clapper.

The proper shape for a bell is a subject of as much discussion as the composition of the metal. Most founders believe that the well known "bell shape" is better than any other; but the proportion of the several parts is only empirical or conventional. The German founders are said to adopt a formula in which, if the thickness of the sound-bow be called one, then the diameter of the mouth must be fifteen, the diameter of the top seven and a-half, and the height twelve; moreover, the weight of the clapper is to be one-fortieth that of the bell. English founders do not agree on this point, each having a favourite formula of his own. Mr. E. B. Denison, at a meeting of the Institution of British Architects some years ago, described experiments made to ascertain the fitness of various forms to give forth sonorous tones; he tried hemispheres, cylinders, gongs, tuning forks, springs, spirals, and flat plates, and arrived at a conclusion that, with a given weight and a given constitution of metal, the ordinary bell shape sends out the sound to a greater distance than any of them. The Chinese bells are more nearly cylindrical than those of Europe. Réaumur, inventor of the thermometer bearing his name, differed alike from the European and the Chinese founders. He was of opinion that the segment of a sphere would be the best form; his judgment was based on the fact that a mass of lead, left to cool in a hemispherical ladle, is more sonorous than any other form that can be given to that metal. This reasoning, however, is inconclusive, seeing that the mass of lead is solid, not hollow like a bell, and seeing moreover that lead is one of the least sonorous of metals. A singular form was given to some bells cast in the British Islands in early times, and occasionally brought to light by antiquaries. Each bell was made of thin plates of hammered iron, beat into a four-sided form, brazed or bronzed, and fastened with rivets. A choice little bell of this kind is known as the *Clog-an-Eadhachta-Phatraic*, or "Bell of St. Patrick's Will," mentioned in the Irish chronicles as early as 553 A.D., and supposed to have belonged to St. Patrick. This bell, six inches high, five broad, and four deep, is preserved at Belfast in a casket or shrine made about the year 1100, enriched with gems and with gold and silver filagree. Another four-sided bell was conveyed by an Irish missionary to Switzerland about 630 A.D., and is preserved in the monastery of St. Gall. The Archæological Museum at Edinburgh contains two or more specimens of these curious four-sided hand-bells.

The Founding or Casting of Bells.

A consideration of the musical pitch of the sound emitted by bells will be better understood when the process of manufacture has been described.

Setting aside minor changes and improvements introduced from time to time, the routine is as follows. When the designer has arranged for the height, width, thickness, and shape of the bell, gauges or contour pieces of wood are prepared to serve as guides during the manufacture. A pit is dug in the earthen floor of the foundry shop for the casting of one large bell, or two or more of smaller dimensions. Supposing it to be one large bell, a "Great Tom" or a "Big Ben," a rough centre of brickwork is built up in the pit, approximately corresponding in shape with the intended bell, but somewhat smaller than its internal diameter. This centre is coated with a particular kind of moulding clay or loam; and the gauges or contour pieces are drawn around it, scraping away superfluous clay, and leaving a smooth and equable surface. On this surface the name of the founder, the date of founding, and such inscriptions and ornaments as may be designed are stamped, sharply and well defined —to appear *in relievo* on the finished bell. When this coated core or centre has been thoroughly dried, it is coated a second time with clay or loam; the thickness of this coating at all parts is made equal to the intended thickness of the metal, and has therefore to be regulated with much nicety. The true adjustment of thickness is insured by the use of other gauges or contour pieces, which scrape off superfluities and produce a well curved and finished surface. It thus results that this shell of clay corresponds on its inner surface with the inside of the bell, and on its outer with the outside, so far as size and shape are concerned. A little dry tan-dust sprinkled over the core prevents the two portions of clay from adhering—a precaution the necessity for which will presently be understood. The shell being dried, and another sprinkling of tan-dust applied, a third coating of clay is laid on; this is of considerable thickness, but need not be trimmed off to any particular shape on the outside. The brick centre is by this time clothed in three coats—inner, middle, and outer; and the whole mass is left quiet until thoroughly dried. The outer coat can then be lifted completely off, because the consistence of the clay enables it to hold well together, and because the sprinkling of tan-dust prevents adhesion between the outer and middle coats. The middle coat is then picked off piecemeal, exposing the smooth uninjured surface of the inner coat. The combined result of these operations is well compared to the placing one within another of three earthenware basins differing slightly in diameter; when the middle basin is removed a concentric cavity exists between the inner and outer basins. Similarly in the case of the bell; when the middle coat has been picked away, and the outer coat carefully re-adjusted, there is left an analogous concentric cavity between the inner and outer coats. This cavity or annular ring of space exactly represents the intended height, diameter, thickness, and shape of the bell. When the mould has thus been completely finished in the casting pit the remainder of the pit is filled in with loam, openings being left for the admission of molten metal and the exit of air.

The furnace in which the bell metal is melted is adjacent to the casting pit. The copper may be old ships' sheathing, clippings, and scraps of various kinds, combined with blocks of quite new metal; the tin is usually in the form of slabs or ingots. The furnace is of the reverberatory kind, reflecting the flame and heat of the fire from the roof down upon the metal to be melted; the fuel is billet wood, to avert the injurious effects that might result from the use of sooty coal. When thoroughly melted to a glowing temperature, the liquid fiery stream is allowed to flow from the furnace to the orifices in the mould, until the annular cavity is completely filled.

Right cheerily does Schiller, in his "Song of the Bell," throw the foundry operations into a lyric form. The poem comprises too many stanzas to be transcribed here; but the following may be given as one English translation of three of them:

"Fast immured within the earth,
Fix'd by fire the clay mould stands;
This day the bell expects its birth:
Courage, comrades! ply your hands!
Comrades, ceaseless from your brow,
Ceaseless let the sweat-drop flow;
If by his work the master's known,
Yet heaven must send the blessing down.

Billet of the fir-wood take,
Every billet dry and sound,
That flame, a gather'd flame awake,
And vault with fire the furnace round;
Quickly cast the copper in,
Quickly cast due weight of tin,
That the bell's tenacious food
Rightly flow in order'd mood.

Ha! the rising bubbles tell
Metals mingling, melting well;
Salt of ashes lightly throw,
So the fused ore shall flow.
Quickly from the scum and froth
Cleanse away the whitening broth,
That from metal pure and choice
May swell the full sonorous voice."

The metal is allowed to cool very slowly, especially if the bell be of exceptionally large dimensions, in order to insure toughness and good annealing; and then it is extricated from its prison house. Messrs. Mears, of Whitechapel, are the principal founders in this country; they have cast the largest bells in England, those of the Houses of Parliament and of York Minster; also the great bell for Montreal Cathedral, which took twelve days to cool in its mould.

Several bells of moderate size are, as we have implied, cast in one pit, each with its mould built up on the floor of the pit. One furnace will suffice for one pit; but when a bell of large dimensions and great weight is to be cast, two furnaces share the duty of supplying the molten metal, channels being formed from each of them to the feed orifices in the mould.

The Sound or Musical Pitch of Bells.

In order not to interrupt the description of the manufacturing processes, we have reserved to the present section a notice of that very interesting part of the subject—the mode of determining the sound or tone of a bell.

This sound depends for its acuteness or graveness, its high or

low musical pitch, conjointly on the diameter, height, and thickness. The thickness of two bells being equal, the larger will yield the lower tone; whereas, if the other dimensions are equal, the thinner bell yields the lower tone. The molecular condition of the metal has an influence which is not explicable to bell-founders, and which sometimes occasions them much embarrassment. Thus, the Royal Exchange bell is said to have disappointed its founder both in the pitch and the quality of its sound. Past experience enables a founder to guess pretty nearly the dimensions necessary for a bell to emit a particular tone; but as he cannot do this exactly, he trims the bell after casting by means of a sharp-pointed hammer, reducing the diameter at the lower edge when the tone is too low, and reducing the thickness at the sound-bow when the tone is too high. It is calculated that to produce a peal of four bells, giving the four notes of the common chord (such as C, E, G, C, in the key of C; or E, G♯, B, E, in the key of E), the diameters ought to be in the proportion of 30, 24, 20, and 15, and the weights in the proportion of 80, 41, 24, and 10, the height and thickness varying in due gradations. A large thick bell yields the same note as one smaller and thinner; but the sound is richer in quality, and penetrates to a greater distance. Many connoisseurs believe that modern bells are "starved," in comparison with those made for cathedrals and churches in the middle ages; that is, that a pre-arranged tone is produced by a smaller and thinner bell, instead of one somewhat larger and thicker, in order to economize metal. It is quite true that the same *pitch* of tone may be thus produced, but not the same *quality*, the sound of the thinner bell being comparatively poor, less mellow, and less penetrating. Great Tom of Lincoln is smaller than St. Paul's bell, but nevertheless yields a higher tone, because made of thicker metal.

There is some reason for believing that the rich tone of many an old church bell is due, in part, to the effect of age and long ringing. The blows which a bell receives century after century, if not so violent as to produce fracture, improve the sonorous quality of the metal by bringing about some unexplained modification in molecular aggregation. That such a result makes itself apparent in other cases is well known. The old pipes of a church organ, the old sounding-board of a pianoforte, the old body of a Cremona violin or a Steiner violoncello, are believed to owe much of their richness and mellowness of tone to molecular changes induced by time and frequent playing.

One slight effect is produced on the quality of a bell-tone, though not on its pitch, by the kind of hammer or clapper with which the blows are given. The Chinese bells are struck with wooden hammers, in the same manner as their gongs; the sound is not so loud as when a metal hammer is used, but is smoother and more melodious.

The mode of suspending a church bell in a tower so as to enable the sound to penetrate to a considerable distance is a practical question of considerable importance. The primary purpose was to invite the worshippers of a whole parish or district to attend divine service, or to pray at once at their own homes; and the more the sound was diffused the better was this notice likely to be heard. Some difference of opinion has arisen among architects and ecclesiologists as to the best mode of realizing this purpose. That sound is most diffusive when its source is well elevated above the level of the ground is generally admitted, seeing that it escapes some of the interruptions caused by houses, trees, and other intervening objects; but the question is, whether the room appropriated to the reception of the bell should form part of the church or cathedral, and participate in its general architectural character, or whether it should be in an isolated tower. The Gothic architects of the middle ages, instead of elevating the bells into a chamber belonging to the general constructive features of the building, often deemed it expedient to erect a separate tower, called a *campanile*, *belfry* or *bell-tower*, at a little distance. There cannot be a question that some of these old campaniles are graceful adjuncts to a church, sharing the creative genius lavishly bestowed on the main structure. Canterbury, Chichester, Ledbury, and Beccles are among the places in England where these campaniles still exist; but in some instances, as that of Salisbury Cathedral, the old detached structure has been taken down, and a bell-room formed in the main structure as a substitute. It is more than doubtful whether this change was an improvement; nay, we may be certain that the builders of that noble edifice knew better what they were about than later architects, who endeavour to "improve" upon them. The central towers of cathedrals and large churches were, it is now believed, intended chiefly as lanterns to admit light into the body of the building; and where such towers have been converted into belfries, the interior suffers in regard both to light and to appearance.

The Inscriptions on Bells.

Most large bells have mottoes as well as names; and the inscriptions recording these mottoes fill a curious chapter in bell literature.

Every distinguished bell-founder (many of them connected with monastic institutions) had his favourite ornamentation and monograms; and they vied with each other in the quaint Latinity of their inscriptions—sometimes fanciful, sometimes pious, sometimes descriptive. The oldest bell bearing a date, so far as is known, is the Fribourg bell of 1258; its inscription is:—

> "O Rex gloriæ; veni cum pace; me
> Resonante, pia populo succurre Maria!"

Many of the old bells dedicated to saints are inscribed with the invocation,

> "Ora pro nobis."

An inscription much admired by the old ecclesiastics, enumerated six uses subserved by the bell of the church, cathedral, monastery, or chapel:—

> "Laudo Deum verum, plebem voco, congrego clerum,
> Defunctos ploro, pestem fugo, festa decoro."

Another inscription carries this list to nearly twenty varieties of use:—

> "En ego campana, nunquam denuntio vana,
> Laudo Deum verum, plebem voco, fulmina frango,
> Vox mea, vox vitæ, voco vos, ad sacra venite,
> Sanctos collaudo, tonitrua fugo, funera claudo,
> Funera plango, fulgura frango, Sabbatha pango,
> Excito lentos, dissipo ventos, paco cruentos."

Some of these have appeared in English dress, with modifications; such as:—

> "To call the folks to church—I chime.
> When mirth and joy are on the wing—I sing,
> When from the body parts the soul—I toll!"

And the following:—

> "Men's death I tell by doleful knell;
> Lightning and thunder I break asunder;
> On Sabbath all to church I call;
> The sleepy head I call from bed;
> The winds so fierce I do disperse;
> Men's cruel rage I do assuage."

These inscriptions point to the multitude of meanings attached to bell sounds in former times. That the tones of church bells would drive away thunder and lightning was a belief firmly held, not only by the humble and illiterate, but by bishops and priests of the Church; and they were conceived to be equally efficacious for exorcising demons and evil spirits. The prelates baptized church bells, not only because of their religious associations, but to impart to them a more vigorous aptitude to drive away devils and tempests. "The Golden Legend" expresses this in the quaint old English of Wynkyn de Worde's days:—"It is said that the evil spirytes that ben in the region of th' ayre doubte moche wen they here the belles ringen when it thondreth, and when grate tempeste and rages of wether happen, to the ende that the feinds and wycked spirytes should ben abashed and flee, and cease of the makyne of tempeste." The great bell of St. Paul's, shortly after it was set up in its place, was sometimes rung during thunder-storms; and the inhabitants around believed that the ale in their cellars would turn sour when they heard this indication. The ringing was also adopted during eclipses, under an impression that the sound would drive away the wicked demons who were hiding the light of the sun or moon. Long after the belief in such things was abandoned by persons of any culture, it was a custom at Durham Cathedral for the choristers, in their surplices, to ascend to the belfrey on the eve of Corpus Christi, and there to sing a Te Deum. It was to celebrate an event which is said to have taken place some four or five centuries ago, when a fire broke out in the cathedral while the monks were at midnight prayer; it raged in the tower for many hours, and yet did not touch the belfry room or the bell—a sure proof, of course, that the sound of the bell drove away the fire. Even so late as twenty years ago, the Roman Catholic Bishop of Malta ordered the church bells to be rung during a thunder-storm. The shrewd Fuller, as a means of pointing out the invalidity of this attribution of storm-repelling power to church bells, mentioned that many abbey churches had been destroyed or injured by lightning, in spite of the bells which they carried.

Some of the English bell-inscriptions display a somewhat lame attempt at moralizing; such as:—

> "Mankind like us too oft are found
> Possessed of nought but empty sound;"

and,

> "When backward rung I tell of fire;
> Think how the world shall then expire."

The names of the founders, or of the donors, or both, are often found in bell-inscriptions :—

"My sound is good, my shape is neat ;
Perkins made me all complete."

Of course to the honour and glory of Perkins. Another evidently refers to the donor :—

"I'm given here to make a peal,
And sound the praise of Mary Neale."

In another, the donor of a prosaic but substantial sum of money is handed down to posterity :—

"All ye who hear my solemn sound,
Thank Lady Hopton's hundred pound."

Bad grammar is the chief merit of the following :—

"John Martin of Worcester he made wee,
Be it known to all that do wee see."

Some make an attempt at smart witticism, such as this, on a tenor bell :—

"I am the first, altho' but small,
I will be heard above you all."

One, fitted for a book of smart sayings, seems a little incongruous on a church bell :—

"Pull on, brave boys ; I am metal to the back-
Bone ; I'll be hang'd before I'll crack."

Another displays such ignorance, such poverty of thought, that we may well marvel how it was permitted to appear on a church bell ; perhaps one of the churchwardens was the poet :—

"John Draper made, as plainly doth appeare,
This bell was broake & cast agayne
Which tyme churchwardens were
Edward Dixon for the one
Who stode close to his tacklin,
And he that was his partner then
Was Alexander Tacklyn."

Bell Peals and Bell Chimes.

A curious matter connected with bells is *campanology*, the art of bell-ringing. It consists, not in ringing out a melody from a series of well-attuned bells, but in ringing them all, over and over again, in varying order or succession. If four balls or counters of different colours are placed on a table, we may arrange them in a line of four in no less than twenty-four different ways. There might, for instance, be six series beginning with white ; viz. white, black, red, blue ; white, black, blue, red ; white, red, black, blue ; white, red, blue, black ; white, blue, black, red ; white, blue, red, black. There might be six others beginning with black, six with red, and six with blue. If the number of balls is increased to six, eight, ten, twelve, &c. the number of possible changes in arrangement increases with almost incredible rapidity, due to the arithmetical law of combination and permutation. Now the same thing occurs if we use bells of different tones, instead of balls of different colours. A "peal" of bells varies from two to twelve in number, all differing in tone. Sometimes each ringer manages two bells, by means of two ropes ; but usually there are as many ringers as bells, with one to act as captain or leader. Much power of endurance is required in the arms to bear the fatigue of rope-pulling for an hour or several hours, and strict attention to the exact moment when the sound of each bell is called for. The English ringers (for this is especially an English art) pride themselves in varying the changes in a surprising number of ways. They never give all the variety possible with a definite number of bells ; some would be wanting in musical or pleasing quality and are therefore omitted. A skilful campanologian selects such as please his taste ; and if approved by the fraternity generally, the selection becomes known by name.

At Exeter Cathedral there are ten bells, the smallest of which weighs 8 cwts. the largest 67 cwts.—great weights to set swinging to and fro. Much more frequently the number is eight. The six bells at Christchurch gave rise to the lyric couplet—

"Hark, the merry Christchurch bells,
One, two, three, four, five, six !"

Skilful ringers pride themselves on the number of changes they can get through in a given space of time. We read of special instances, in which 5,040 changes were rung in 3¼ hours, 6,876 in 4¼ hours, 7,000 in 4 hours, 10,008 in 6¾ hours and 14,224 in 8¾ hours. The greatest achievement of all is said to have been 40,320 changes in 27 hours, rung by thirteen men working in relief gangs. Some church turrets contain printed rules hung up in the bell room, to be observed by the ringers, cautioning them to avoid swearing, quarrelling, keeping on their hats, drinking, telling idle stories, making a noise, or over-pulling the bells. This over-pulling occurs sometimes ; the bell makes a complete somersault, perchance breaks from its fastenings, and produces serious mischief by its fall. One of the strange epitaphs which have found their way into collections of this class of literary curiosities points to an instance of a ringer being killed by such an accident. The ringer's brother met with his death about the same time from another disaster ; and the epitaph was made to do duty for both :—

"These two youths were by misfortun serounded ;
One died of his wound, the other was drownded !"

The technical terms sanctioned by the college of bell-ringers are amazing. We say "College," for there is really a society of amateurs, comprising gentlemen and even clergymen, who ring a change occasionally for the pleasure of the thing. The directions given in Treatises on Campanology, for ringing a particular set of changes, involve the use of these technical terms so profusely as to be absolutely unintelligible to persons outside the initiated circle.

Two modes of drawing out the sounds of a set of well-assorted bells call for the use of more mechanism than the mere pulling of ropes. One of these is by the aid of a keyboard somewhat similar to that of a pianoforte or a church organ. A lever at the remote or inner end of each key is connected by other mechanism with a hammer, so poised as to be nearly close to a bell ; when the key is pressed down by the finger the hammer strikes the bell, and the sound is produced. There are as many keys as there are bells ; or it may be that some of the larger bells are struck by hammers worked by foot pedals. The bell ringer, with this arrangement, is really an organist, and can produce any harmonized melody within the compass or register of the peal of bells. Only a few English churches contain bells thus arranged ; on the continent they are more numerous. The other mode of playing is by means of a rotating barrel, something like that of a musical snuff-box or a street organ. The barrel is studded all over with projecting pins, arranged in an order depending on the tune to be played. A spring or a descending weight keeps the barrel rotating ; each pin catches against a lever governing a hammer which strikes a bell ; other levers are all touched during the progress of a tune in such succession as the melody requires. If the barrel is large, the studs may be sufficiently numerous for two or more tunes, played one after another ; and the playing continues until the spring is unwound or the weight fully descended. Many Continental cities contain beautiful sets of bells played on this principle ; England is less fully supplied with them.

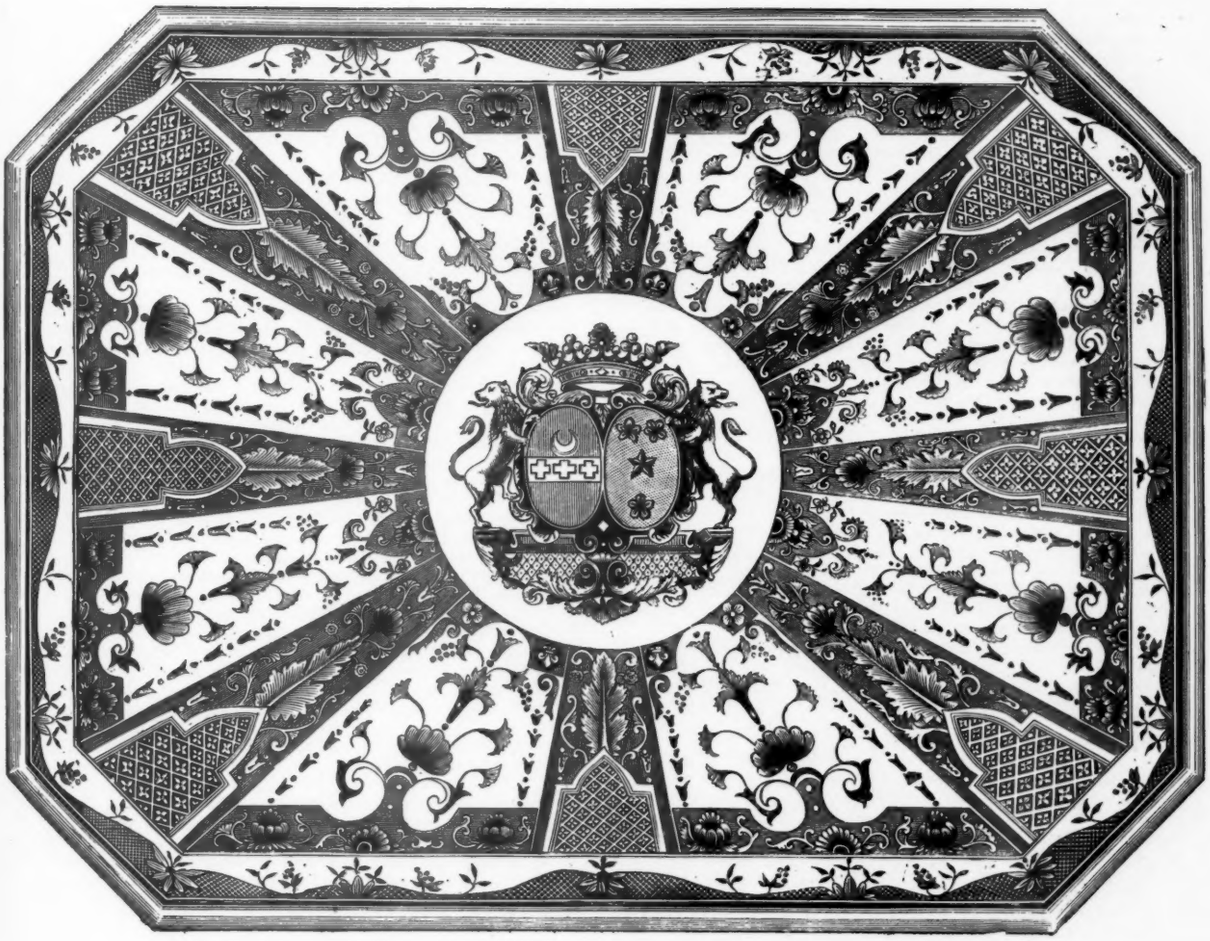
GRANITE, WOOD, OR ASPHALTE ?

London Experience in the Matter of Carriageway Pavements.

AS this subject is one which is of the first importance to all the large towns in the kingdom, and the results of London experience are awaited in many cases before determining roadway changes, we give the elaborate and able report just furnished to the Commissioners of Sewers of the City of London by their engineer, Mr. William Haywood.[1] The Report was made in compliance with the following reference :—

"That the engineer cause observations to be made and particulars taken as to the number of accidents befalling horses on the asphalte, wood, and granite pavings, under as nearly as possible similar circumstances, distinguishing the different results under various conditions of weather, and showing the per-centage of accidents under each circumstance and condition ; also taking note of any other particular he may think desirable, with a view to elicit the greatest possible amount of information respecting the various pavements."

[1] In connection with the subject see also the articles on Asphalt, pp. 106 and 162, vol. ii., and the article on "Street Pavements and Horse-shoes," p. 26, No. 13.



GEMS OF INDUSTRIAL ART.—DISH IN ROUEN PORCELAIN.

After considering the means to be taken for obtaining the desired information with the least delay and expense, I came to the conclusion that the police could be usefully employed for the purpose; accordingly I applied to Colonel Fraser, who expressed his willingness to assist the commission by allowing a certain portion of the police force to take the daily observations, and arrangements were ultimately made with him to this end.

Books were then prepared by me in such manner as appeared best suited to ensure accuracy in recording the traffic and accidents, as well as to reduce the labour of the work. These books when filled up by the police, were placed in the hands of my assistants, who checked the casts, and arranged the figures, so as to enable me to prepare the summaries and tables which are herewith submitted.

Forty-three men were employed altogether in taking the observations of traffic and accidents, thirty-eight of whom were constables. The constables acted under the inspection of four sergeants, and their duty was so arranged that inspection was never taken off them. The whole service was directed and superintended by the chief inspector of police.

The observations taken were :—

Firstly.—Of the traffic : the number of horses and vehicles which passed through the selected streets.

Secondly.—Of the accidents which occurred to the horses.

I. TRAFFIC.—For ascertaining the traffic two men were stationed at each point of observation, and on opposite sides of the way, each man taking the traffic on the side of the road which was nearer to him and passing in one direction only. The men were employed for three hours at a time, and were then relieved by others for three hours ; and there were, therefore, altogether four men employed during the day at each point of observation. Each man was on duty for six hours daily. The observations were taken from 8 a.m. to 8 p.m., a period of twelve consecutive hours.

Observations of the main streams of traffic were taken at each selected spot for two consecutive days in a week ; and were followed by two other days' observations in the week after ; but on different days to those of the preceding week. They were carried on in such order until six days' observations, including every day in the week (Sundays excepted), had been taken at each point. Observations of cross or collateral traffic were also taken sufficiently to enable the effect on the general stream of traffic to be ascertained.

Whilst the traffic was being taken none of the streets in the vicinity of the main thoroughfares under observation were materially obstructed for paving or other works, and the traffic was therefore in its normal state.

II. ACCIDENTS.—The number of men employed in taking account of the accidents was thirty ; fifteen being on at a time. The relief took place every three hours, and the men were subject to the same supervision by the inspectors and chief superintendent as those taking the traffic.

The observers were stationed at such points as enabled each man to see easily the area assigned to him without moving far from a central position. These points had been fixed after careful observation by myself, so as to ascertain the area which could be properly watched. Each man recorded all the accidents which occurred on his assigned area.

Owing to differences in the extent and nature of the traffic, the width of streets, and other conditions, the length of thoroughfare assigned to the men varied from 239 feet to 636 feet, and the areas from 640 to 2,071 yards superficial ; the mean of the whole being one man to every 333 feet lineal and 1,226 yards superficial of carriageway pavement. These lengths and areas are shown on the plan accompanying this Report, and also in Table A in the Appendix.

The observations of accidents were commenced on the 10th March last, and continued until the 5th April, during which time the weather was generally fine. As there was no appearance of change in the weather, and it being in the highest degree desirable to have observations during all kinds of weather, they were then discontinued. On the 9th May, as rainy weather appeared likely to ensue, they were resumed, and continued until the 7th June. The weather, however, became again fine, and continued for the most part so until the observations were completed. They were discontinued because police arrangements did not admit of their being prolonged.

As the horse traffic in the City is much less on Sundays, being in fact in the main streets only from 20 to 30 per cent. of that which passes on other days in the week, the observations were confined to working days alone.

By omitting Sundays there were fifty working days on which observations of the accidents were made.

As the expense would have been largely increased by taking observations during the night ; as owing to the darkness they would have been less reliable ; and as the great bulk of the traffic passes through the City thoroughfares between 8 a.m. and 8 p.m., observations of accidents were made only during those twelve hours of day.

During the first three weeks the accidents were recorded without explanation of their nature ; but as a large proportion of the horses were observed to fall only on their knees, the accidents on the remaining thirty-two days were classified under the heads of *falls on knees*, *falls on haunches*, and *complete falls*. No notice was taken of the mere slipping of a horse.

The weather during the observations will now be generally described, for whatever be its character, weather affects the surface of all pavements, and largely influences the conditions under which slipperiness varies.

The direction of the wind varied during the fifty days ; but was principally either from the north, east, or north-east. The prevailing direction was north-east.

The mean temperature of the twenty-four hours, as taken from the Registrar-General's returns during the period, varied from 34·5° to 60·9°. The observations of temperature taken in Guildhall Yard by me daily at 9 a.m. and 3 p.m., show a variation of from 35·7° to 64·8°. The mean daily temperature was for the most part somewhat below the average.

Out of the fifty days there were but seventeen days on which rain fell. On the average there are 150 days annually in London in which rain falls at some period during the twenty-four hours ; therefore, during the fifty days' observations there was proportionately less than the usual number. I find also there was a less number of rainy days than the average during those particular months, and that the quantity of rain was far less than usual. This is a fact much to be regretted, inasmuch as the slipperiness of all pavements is very much affected by moisture, although in different manners and in different degrees. The character of the weather will be further dealt with in another portion of the report.

The reference to me being to take observations of the accidents befalling horses on asphalte, granite, and wood, and there being a variety of each of these classes of pavement, on each of which the slipperiness varies, it became necessary in the first place to determine which to select, and I ultimately chose one of the compressed asphalte of the Val de Travers Company, and one formed of 3-inch Aberdeen granite cubes ; these two kinds being the best known and the most extensively used in London of their several classes. I also selected the improved wood pavement, this being the only one of which there was any large quantity laid down in the City ; and a specimen of the Ligno-Mineral pavement, which lay adjacent to it.

It would have been desirable to have had observations taken in streets of similar width and gradient, of which the pavements were in equally good condition of repair, and the traffic passing over them as nearly as possible the same in character and extent, as comparisons would then have been more easily made, and discrepancies more readily accounted for. This similarity in conditions was unattainable ; and after giving the subject much consideration, I selected Cheapside and the Poultry, King William-street, part of Gracechurch-street, and the eastern portion of Cannon-street, of which the surface conditions generally were :—

ASPHALTE.—Cheapside and the Poultry were paved with the compressed asphalte of the Val de Travers Company, laid 2¼ in. thick, on a bed of concrete 9 in. thick. The surface of this pavement was in good condition.

The total length of these two thoroughfares was 2,033 feet, and the area of the carriageway 6,914 yards superficial. The worst gradient was on a length of 48 feet next to St. Paul's Churchyard, which was 1 in 58. The other gradients varied from 1 in 66 to 1 in 550 ; nearly the whole length of the two thoroughfares being less steep than 1 in 70.

The traffic in Cheapside and the Poultry was of a mixed character, including a considerable number of omnibuses. It was for the most part slow, especially in the Poultry.

GRANITE.—King William Street from Cannon Street to Lombard Street, and Cannon Street from King William Street to Walbrook, were paved with Aberdeen granite. The stones were 3 in. wide, 9 in. deep, and from 9 in. to 15 in. long, laid so as to touch each other ; the joints being filled in with stone lime grout. The pavement of Cannon Street was a little out of repair ; that of King William Street in a bad state of repair. The latter was under order to be replaced by a new pavement, —which has since been laid.

The pavement in King William Street was 675 feet long, and had an area of 2,379 yards. A length of 138 feet at its northern end had a gradient of 1 in 54, the remainder was from 1 in 68 to 1 in 1,000.

The traffic in this part of King William Street was much the same in character as that in Cheapside and the Poultry, but on the average, it passed through it at a greater speed than in the other thoroughfares under observation.

The portion of Cannon Street under observation was 807 feet long, and its carriageway had an area of 2,752 yards. A length of 326 feet at the western end had gradients of 1 in 30 and 1 in 31. The remainder varied from 1 in 61 to 1 in 841.

The traffic in Cannon Street was generally slow; a large number of one-horse vehicles passing through it, and only a few omnibuses. Carts stopped for loading and unloading in front of the premises on the southern side of the street during the largest portion of the day.

WOOD.—The wood pavements under observation were two in number; that of the Improved Wood Paving Company, and that of the Ligno-Mineral Paving Company (Trenaunay's patent).

King William Street from London Bridge to the Statue, and a small portion of Gracechurch Street, were paved with the improved wood pavement, which is formed of fir blocks, 3 in. wide, 5 in. deep, and 9 in. long. The blocks are laid touching each other at their ends, but crosswise of the street, the joints are ¾ in. wide, filled in with fine clean gravel, and then grouted with a bituminous composition. The total length of this pavement was 1,394 feet, its area 5,937 yards. Its surface was in excellent condition.

A length of 130 feet of this pavement near to Crooked Lane had a gradient of 1 in 30. Near to Eastcheap was a length of 83 feet with a gradient of 1 in 34. The remainder varied from 1 in 37 to 1 in 260. Near to the statue of King William IV. the pavement had also in several places a steep transverse slope.

The pavement in Gracechurch Street of the Ligno-Mineral Paving Company consisted of beech blocks, 3½ in. wide, 6 in. long, and 4½ in. deep, laid with longitudinal and transverse joints ½ in. wide; the wood was mineralized, and the joints were filled in with cement or lime grout. It was laid on a bed of concrete 5 in. thick. The surface was in good condition.

The length of the ligno-mineral pavement was 87 feet, the area 410 yards, and the gradient 1 in 49.

The traffic over the wood pavements in King William Street and Gracechurch Street comprised vehicles of all descriptions, and in King William Street included very much of that which passed through the other thoroughfares under observation. The traffic passed generally at a slow rate; but from Arthur Street to London Bridge during two or three hours of the day it was less slow in the centre of the street.

It is necessary to make some further remarks in reference to these wood pavements.

When I included for observation the two kinds described, I did so because it was desirable to observe considerable lengths of street. The pavements were adjacent to each other, and could be conveniently watched from one station. It did not then occur to me that there was any material difference between the two in respect of safety; but as investigation into the causes of the accidents advanced, and the various abstracts and tables were made up, a very remarkable difference became apparent. I do not feel justified in leaving out the observations taken on the ligno-mineral pavement, and the accidents which occurred on it are accordingly included with those which occurred on the improved wood pavement, and they are given together in the totals and general results. If there had been no more than a trifling difference between them in the proportion of accidents I should have taken no notice of this difference, for looking at the mixed causes which lead to accidents it might not have been practicable to do so usefully; but the excess of falls on the ligno-mineral is so great as materially to alter the relative position of the wood to the other pavements as regards safety. Although, therefore, as before said, the general tables include the accidents on both, it has been necessary to separate them in various parts of the report to prevent erroneous conclusions being drawn.

The lengths and areas of the thoroughfares under observation will be found in Table B in the Appendix.

All the pavements during the period of observation were cleansed every morning, and were also cleansed constantly during the busiest hours of the day by street orderlies. The asphalte was occasionally, but not frequently, washed in the morning; and all the pavements were, therefore, as clean as the nature of their respective surfaces admitted, with the amount of labour and expense which was ordinarily bestowed on them. No measures were taken to keep them cleaner than the other main thoroughfares in the City.

It was frequently noticed that accidents occurred on the asphalte when it was dry, owing to the horses putting their feet on fresh droppings; but scarcely any appear to have taken place from this cause either on the granite or the wood.

During the period of observation the asphalte was not watered to lay the dust; it not being customary to water that material; but the granite and wood were watered the same as other thoroughfares of the City.

Some of the accidents on the wood were undoubtedly attributable to the moisture caused by this surface-watering, but accidents attributable to a similar cause do not appear to have taken place on the granite pavement.

The asphalte when the surface was damp or slippery was occasionally strewn with fine sand by the street orderlies; but this sand was used sparingly, and owing to the state of the weather the necessity for using it was small.

The improved wood pavement was on four occasions during the observations slightly strewn with fine gravel. This was done by the contractors to indurate the surface, in the way customary with wood pavements. On only one of the four occasions was the pavement in such a state that strewing gravel was likely to be useful to prevent accidents.

Nothing was strewn either by the contractors or by the commission on the ligno-mineral pavement during the time it was under observation.

In the calculations, which are based on the extent of traffic, the mean traffic arrived at by observation has been taken to apply to the whole time during which the observations of accidents were made. It would of course have been more strictly correct to have made daily observations of the traffic throughout the whole period simultaneously with those made of the accidents; but to have made them would have largely increased the expense, and experience has shown that it is unnecessary to prolong such observations for the purpose of obtaining averages.

It is assumed in this report that each horse traversed the entire line under observation. Each line was carefully defined, measured, and separately calculated. For example, at the western end of Cheapside there were three streams of traffic, each stream having a different length of journey. On each of these the number of horses and the accidents occurring to them were separately recorded, and the mileage travelled by the horses ascertained. The same was the case near to the statue in King William Street, where there were various lines of traffic, all of which were dealt with in a similar manner. The collateral traffic was not taken for any length of time; to have done so would have much increased the expense, but it was taken at every cross street, so as to learn how the average number of horses passing through the main line was affected by it, and the variation in numbers was found to be, generally speaking, as much on the one side as on the other. As the observations on the main lines were all taken from points selected, so as to include the collateral traffic as far as practicable, it is believed that a very correct average of the whole has been obtained.

It has now to be stated, that although the scope of the reference is wide, yet in writing this report I have thought it desirable to keep closely to the manifest object of the reference, which is, as I understand it, *to ascertain by direct observation the relative safety of the three classes of pavement.* I have therefore not referred to statements made from time to time to the Commission, either by the owners or drivers of horses, the proprietors of pavements, the police, or the public, as to the safety of particular pavements. Nor have I referred to previous observations or to other information already before the Commission on the subject; but have dealt simply with the results of the observations specially made for this report.

I have also avoided entering on the advantages and disadvantages generally of the different kinds of pavements. To have done so would have made this report an essay on pavements rather than a report on the accidents occurring on them. I have avoided, as far as possible, giving opinions of my own on the matter; though it has been essential to draw attention to *those conditions under which the pavements differ from each other*, and for which difference due allowance will have to be made in judging the results. Had I not done so, the general results given in some of the tables might have been taken as applicable to similar pavements under all conditions and seasons; which would have been erroneous.

A plan is appended (in the original) showing the pavements which were under observation, their nature and gradients, with the horse traffic which passed at certain places, and it contains other information explanatory of the report.

The most important of the abstracts by which the tables and summaries are arrived at, and from which the conclusions set forth in the report are drawn, are also appended (in the original). By reference to these abstracts the details of the observations will be seen. These abstracts are:—

A.—Table showing length and superficial area of carriageway pavement observed from each station.

B.—Table showing the lengths and superficial areas of the thoroughfares in which the observations of traffic and accidents were taken.

C.—Table showing the number of horses and vehicles passing through various thoroughfares during twelve hours, from 8 A.M. to 8 P.M.

D.—Table showing the mean numbers of vehicles drawn by one horse,—two, and three or more horses that passed over the various pavements in twelve hours, from 8 A. M. to 8 P. M.

E.—Table showing the number of horses that fell on the various pavements, between 8 A. M. and 8 P. M., the state of the weather, the direction of wind, and other information, during certain days in March, April, May, and June, 1873.

F.—Table showing the traffic, number of horses that fell, and the distance travelled before a horse fell on each of the various pavements.

G.—Table showing the proportions of horses that fell on knees, on haunches, and completely, on the various pavements, during thirty-two days' observations.

H.—Table showing the number of horses that fell in vehicles drawn by one horse,—two, and three or more horses.

I.—Table showing the total number of horses that fell in vehicles drawn by one horse,—two, and three or more horses, over the three descriptions of pavement.

K.—Table showing the distance travelled by horses in vehicles drawn by one horse,—two, and three or more horses, respectively, before a horse fell.

L.—Table showing the order of slipperiness as compared with the gradients upon each class of pavement.

Throughout the report the pavements are referred to in alphabetical order: asphalte, granite, wood; this being a convenient mode to adopt for general reference as well as for other reasons. They are transposed in some of the tables incorporated in the body of the report, where they have been arranged so as to show more clearly their relative safety.

Having now laid before the Commission a general account of the observations taken, and the manner in which they have been used, I proceed to state the general results.

Traffic.

The horse traffic daily between 8 A. M. and 8 P. M. on the working days in the months of March and April, 1873, during which the observations were taken, are given in Table C in the Appendix; the mean traffic at the most important points on the lines was:—

	Mean number of horses passing in 12 hours, from 8 A. M. to 8 P. M.
Asphalte:—	
Cheapside, east of Milk Street	12,366
Poultry, by Grocers' Hall Court	10,920
Granite:—	
King William Street, by Abchurch Lane	8,555
Cannon Street, by Bush Lane	5,350
Wood:—	
King William Street, north of Arthur Street	21,162
Gracechurch Street, by Talbot Court	11,484

The vehicular traffic was separated in the observations under the heads of *one, two, and three or more horse vehicles*, the details of these observations are given in Table D in the Appendix, but the mean number which passed at the most important parts on the line is given in the following table:—

Table showing the mean number of one, two, and three or more horse vehicles, respectively, passing through the streets under observation in March and April, 1873.

	Mean number of vehicles passing in 12 hours (from 8 A. M. to 8 P. M.)			Total.
	One horse.	Two horses.	Three or more horses.	
Asphalte:—				
Cheapside, east of Milk Street	6,533	2,825	61	9,419
Poultry, by Grocers' Hall Court	5,472	2,637	58	8,167
Granite:—				
King William Street, by Abchurch Lane	4,276	2,006	89	6,371
Cannon Street, by Bush Lane	4,090	585	30	4,705
Wood:—				
King William Street, north of Arthur Street	10,273	4,831	409	15,513
Gracechurch Street, by Talbot Court	5,817	2,469	243	8,529

The proportions of the whole are as follow:—

Vehicles drawn by one horse	71·42 per cent.
" " two horses	26·95 "
" " three "	1·63 "

Some general idea of the character of the vehicles which passed along these thoroughfares, together with the proportion which the several classes bear to each other, are now given. The observations were not taken on the same day as those on which the observations of traffic and accidents were recorded. Nevertheless they fairly represent the proportion of the several classes of vehicles.

Table showing the proportions of the different classes of vehicles passing through the various thoroughfares during 12 hours, from 8 A.M. to 8 P.M., on certain days in November, 1873.

Street.	Per-centage to total traffic.					
	Cabs.	Omnibuses.	Railway vans.	Tradesmen's carts.	All other vehicles.	All vehicles.
Cheapside	38	22	17	8	15	100
Poultry	38	28	13	7	14	100
King William Street by Abchurch Lane	29	22	19	8	22	100
Cannon Street, by Bush Lane	40	2	28	10	20	100
King William Street, North of Arthur Street	19	20	25	10	26	100
Gracechurch Street, by Talbot Court	23	9	31	12	25	100

Accidents to Horses.

The number of accidents, and the average distance travelled before an accident occurred.

The number of horses that fell during the whole period of fifty days, together with the places at which the accidents occurred, and other particulars relating thereto, are given in Table E in the Appendix, and may be identified on the plan attached. The general results are:—

	Total numbers of falls during the fifty days.
Asphalte:—	
Cheapside	932
Poultry	134
Total on Asphalte	1,066
Granite:—	
King William Street	429
Cannon Street	290
Total on Granite	719
Wood:—	
King William Street and Gracechurch Street—Improved Wood Pavement	380
Gracechurch Street—Ligno-Mineral Pavement	162
Total on Wood	542
Total on all Pavements	2,327

Which gives a daily mean over the various pavements during the fifty days, of:—

	Mean numbers of falls daily during fifty days.
Asphalte:—	
Cheapside	18·64
Poultry	2·68
Total on Asphalte	21·32
Granite:—	
King William Street	8·58
Cannon Street	5·80
Total on Granite	14·38

Wood :—	
King William Street and Gracechurch Street—Improved Wood Pavement.	7·60
Gracechurch Street—Ligno-Mineral Pavement	3·24
Total on Wood. . .	10·84

No opinion of value as to the relative safety of the different classes of pavement can however be formed by simply comparing the number of horses which fell in any one thoroughfare with the number which passed through it—or by comparing the falls with those which took place in another thoroughfare; inasmuch as the risk of falling which a horse incurs on a pavement necessarily depends on the length of the pavement traversed. With the view, therefore, of arriving at a correct conclusion, the various streams of traffic, as well as the distances travelled, were taken separately, and thus the exact distance which was passed over before an accident occurred was ascertained. These lengths are given with much other detail in Table F in the Appendix, but the totals in each street are given in the following table :—

Table showing the total distance travelled by horses over the different pavements, and the total number of accidents during the fifty days' observations.

Description and situation of pavement.	No. of accidents.	Distance travelled in fifty days.
		Miles.
Asphalte :—		
Cheapside	932	172,783
Poultry	134	31,022
Granite :—		
King William Street . .	429	54,683
Cannon Street . . .	290	40,884
Wood :—		
King William Street and Gracechurch Street—Improved Wood Pavement .	380	169,690
Gracechurch Street—Ligno-Mineral Pavement . .	162	9,461
Total . . .	2,327	478,523

The aggregate distance travelled by the horses included in the fifty days' observations was, therefore, 478,523 miles. The general result was that a horse might during that time have been expected to travel along the three pavements—in the proportions due to their lengths—a distance of 205 miles before an accident occurred.

The distances, however, differed materially on the various pavements, examination showing that a horse might have been expected to travel on the—

	Distance travelled before an accident occurred.
	Miles.
Asphalte :—	
In Cheapside	185
In Poultry	231
Mean of the Asphalte .	191
Granite :—	
In King William Street	127
In Cannon Street	140
Mean of the Granite .	132
Wood :—	
In King William Street and Gracechurch Street—Improved Wood Pavement . . .	446
In Gracechurch Street—Ligno-Mineral Pavement	58
Mean of the Wood .	330

The order of slipperiness during the fifty days was, therefore, ascertained to be :—

	Distance travelled before an accident occurred.
	Miles.
1. Granite	132
2. Asphalte	191
3. Wood	330

The observations therefore show that a horse might have been expected to travel before it met with an accident the least distance on the granite, a greater distance on the asphalte, and the greatest distance on the wood.

These figures are correct as far as they go; but to adopt them as determining the relative slipperiness of the various pavements without considerable limitation and correction would be unsafe. To arrive at a correct opinion it is necessary to make further investigation, in order to see whether any portion of the accidents was due to conditions in which one pavement was more favourably circumstanced than others, apart from the difference resulting from the material of which the pavement was composed. Above all it is necessary to ascertain whether the general results would have been changed *if the observations had been extended over a much longer period of time, including other seasons of the year, and every description of weather.* With that object the accidents are now investigated and considered under the following sections :—

1. Nature of the accident to horses.
2. Effect of harnessing.
3. Effect of rate of travel.
4. Effect of gradient.
5. Effect of condition of surface repair.
6. Effect of surface cleanliness.
7. Effect of weather on the surface.

Before proceeding, however, to these separate considerations, some further information, derived from the observations, may be usefully given.

It might have been expected that a large proportion of accidents would have occurred at or near to the point of junction of one pavement with another of different character. The observations show that such was not the case to any material extent, excepting in King William Street, at the junction of the asphalte with the granite. Even in this case investigation assigns other conditions as in some degree accounting for the large proportion of falls which occurred at that spot.

It might also have been anticipated that many accidents would have occurred at points where the collateral traffic either joins or leaves the main stream; for at those points a horse has not only a direct draught, but has to exert force laterally, and withstand the drag of the vehicle in turning, which in the City streets usually causes the wheels to grind against the kerbstones. The returns show that although near to the junction of Bow Lane, Bread Street, and Gutter Lane a somewhat large number of accidents took place, yet at Wood Street, Foster Lane, and Friday Street, where there was a larger collateral traffic, no such excess occurred. Indeed, looking at the returns it would seem that the collateral traffic led to accidents to the horses moving on the main line, by causing them to be pulled up suddenly, rather than itself suffering accidents from turning into or out of the main line. It is probable that the superior safety on the asphalte in the Poultry to that in Cheapside is attributable in some degree to the absence of much collateral traffic, although the slower rate of travel in the Poultry was the most important element in causing that result.

Nature of the Accidents to Horses.

It has already been stated that the accidents were at first recorded without explanation of their character, but that for thirty-two days they were taken under the respective heads of "*falls on knees*," "*falls on haunches*," and "*complete falls*."

The inconvenience caused to the general traffic of a street by an accident to a horse differs materially. A horse which falls on the knees generally recovers itself speedily, and creates but little obstruction. One which falls on the haunches, and especially on a pavement with little joint or foot-hold, recovers itself with more difficulty, and is longer in doing so than if it falls on the knees; whilst if it falls on the side it has more frequently than otherwise to be unharnessed before it can regain a standing position, and, therefore, causes more obstruction than either of the other classes of accident.

It is probable that the injury to horses is greater when they fall on the haunches than when they fall on the knees, owing to the strain to which they subject themselves when attempting to rise. This is especially the case when they are in single harness drawing heavily-laden two-wheeled vehicles and fall on a pavement without joints. Complete falls, if sudden and sharp, are probably still more injurious when the pavement on which the accident takes place is a very hard one. Facts on these points are difficult to obtain, but the matter is worthy of serious consideration.

Details of the accidents are given in Table G in the Appendix, but the following table gives the general results :—

Table showing the numbers of falls on knees, on haunches, and complete falls on the three pavements during thirty-two days' observations.

Description of pavement.	Falls on knees.	Falls on haunches.	Complete falls.	Total falls.
Asphalte . . .	140	107	190	437
Granite . . .	135	22	134	291
Wood . . .	277	10	39	426
Total . . .	552	136	363	1,054

Which gives the following general proportions, viz. :—

Falls on knees	. .	52·37 per cent. of total.
Do. on haunches	. .	13·19 „ „
Complete falls	. .	34·44 „ „

And separating the accidents as they occurred on the different pavements, the proportions are :—

	Accidents during thirty-two days' observations.		
	Falls on knees.	Falls on haunches.	Complete falls.
	Per cent.	Per cent.	Per cent.
Asphalte :— Cheapside . . . Poultry. . . .	32·04	24·48	43·48
Granite :— King William Street and Cannon Street. . .	46·39	7·56	46·05
Wood :— King William Street and Gracechurch Street'.	84·97	3·07	11·96

This table shows that of *falls on knees* the wood had by far the greatest proportion ; more than five-sixths of the accidents being of this class, and that asphalte had the fewest falls on knees.

Of *falls on haunches* the asphalte had the largest proportion, and was very largely in excess of those on either of the other pavements, and that the wood had the smallest proportion of this class of accident.

Of *complete falls* there were fewest on the wood and most on the granite ; but the difference between the asphalte and granite was in this respect small, and on both asphalte and granite there was something like four times the proportion of complete falls that there were on the wood.

Separating the accidents which occurred respectively on the two wood pavements which were under observation, the following are the results :—

	Accidents occurring during thirty-two days' observations.		
	Falls on knees.	Falls on haunches.	Complete falls.
	Per cent.	Per cent.	Per cent.
Improved wood pavement .	84·00	3·60	12·40
Ligno-mineral pavement . .	88·16	1·31	10·53

Thus it appears generally, that horses travelling on the wood pavement were on the whole subjected to falls of a character less inconvenient to the general traffic of the street, and also less likely to be injurious to the horses, than those travelling on the other two pavements, and that in this respect the ligno-mineral was superior to the improved wood pavement.

It was noticed also, that whatever was the nature of the accident, the horses recovered their feet more easily on wood than they did either on asphalte or granite.

Effect of Harnessing.

Although it but little affects the end for which this report was prepared, it may be interesting to show how the horses to which the accidents occurred were harnessed.

The observations were taken under the heads of one horse—two, and three or more horse vehicles, and are shown by Tables H and I in the Appendix. The general result on all the pavements during the fifty days' observation gives :—

	No. of falls.		Percentage of whole.
Falls in one-horse vehicles .	1,279	or	54·96
Do. two-horse vehicles .	927	„	39·84
Do. three or more horse vehicles	121	„	5·20
	2,327		100·00

Assigning these to the various pavements on which the falls took place, the results were :—

Asphalte :—

Cheapside and Poultry.

	Per cent. of total falls.
Falls in one-horse vehicles . . .	55·81
Do. two-horse vehicles . . .	41·56
Do. three or more horse vehicles .	2·63

Granite :—

King William Street and Cannon Street.

	Per cent. of total falls.
Falls in one-horse vehicles . . .	58·83
Do. two-horse vehicles . . .	36·58
Do. three or more horse vehicles .	4·59

Wood :—

King William Street and Gracechurch Street.

	Per cent. of total falls.
Falls in one-horse vehicles . . .	48·16
Do. two-horse vehicles . . .	40·77
Do. three or more horse vehicles .	11·07

Thus, on all classes of pavement the largest percentage of accidents occurred to horses drawing one-horse vehicles. It has already been shown that vehicles drawn by one horse form the largest proportion of the traffic, being, in fact, 71·42 per cent. of the whole, whereas those drawn by three horses or more are but 1·63 per cent. of the whole ; and therefore, as in previous calculations, it is necessary to ascertain the distance travelled by the various classes of vehicles in order to see what was the actual risk incurred under the different modes of harnessing. These distances are shown in detail in Table K, but the general results are that, during the fifty days' observations, a horse might be expected to travel the following distances before it met with an accident :—

Table showing the average distance travelled before a horse fell, in vehicles drawn by one horse,—two, three, or more horses, respectively.

Asphalte :—

Cheapside and Poultry.

	Miles.
A horse in a one-horse vehicle . . .	179
A horse in a two-horse vehicle . . .	211
A horse in a three or more horse vehicle .	116

Granite :—

King William Street and Cannon Street.

	Miles.
A horse in a one-horse vehicle . . .	138
A horse in a two-horse vehicle . . .	131
A horse in a three or more horse vehicle .	72

Wood :—

King William Street and Gracechurch Street.

	Miles.
A horse in a one-horse vehicle . . .	352
A horse in a two-horse vehicle . . .	349
A horse in a three or more horse vehicle .	165

The result of the fifty days' observations therefore was—

That on all three classes of pavement the greatest risk of accident was to horses in vehicles drawn by three or more horses.

That on asphalte there was more risk of a horse falling in a one-horse than in a two-horse vehicle, but that on granite or wood the risk was very nearly the same, whether the vehicle was drawn by one or two horses.

It may be observed that in the three-horse vehicles the horses were nearly always in single file, and that in the two-horse vehicles the animals were almost invariably abreast, the exception being principally brewers' drays and market gardeners' carts and waggons.

Effect of Rate of Travel.

Fast travelling is the cause of accidents in thoroughfares of much traffic, such as those of the city of London, inasmuch as it frequently involves either sudden reduction of speed or actual stoppage of the horse, which is more or less difficult according to the degree of foothold that the pavement affords. It is more difficult to stop a horse on asphalte than on granite or on wood.

Of the streets under observation, that in which the traffic usually moved with the greatest speed was King William Street from Cannon Street to Lombard Street. The carts which loaded and unloaded there were few.

Cheapside at certain hours of the day and on a portion of its length only had a somewhat quick traffic along its centre, but not so quick as the traffic over the narrow part of King William Street. In the Poultry the traffic was uniformly slow; which fact in some degree may explain the other fact observed—that a horse was shown to travel there before an accident occurred a greater distance than in Cheapside. Both pavements were of the same material and in the same condition of repair.

In King William Street and Gracechurch Street, where they were paved with wood, the traffic during the twelve hours in which observations were taken was, northwards of Arthur Street, for the most part slow, and southwards of that street perhaps a little quicker in the centre during some hours of the day, but not materially so.

The granite was therefore, on the whole, more disadvantageously placed in respect of speed of travel than either the asphalte or the wood; but a careful examination of the accidents does not enable me to state what proportion of these was attributable to this cause; although there is little doubt that in King William Street (granite) some accidents were due to speed, especially as the surface of that pavement was in bad condition.

Effect of Gradient.

The power required to draw a load increases directly a level surface is departed from, but the difference is not appreciable when the gradient is slight. The power varies according to the nature of the road surface, the state of repair, the way horses are laden and harnessed, and other conditions. Speaking generally and in round numbers, it has been demonstrated that a horse can, with the exertion of the same force, draw up a gradient of 1 in 100 about nine-tenths of the load which it can draw on a level surface, and about eight-tenths of the same load if the gradient be 1 in 50. After that the tractive power needed increases more rapidly, for on a gradient of 1 in 30 a horse can draw little more than six-tenths of the same load that it can on a level surface. For practical purposes a road, even if it be paved with asphalte, may be considered to have a safe and convenient inclination at 1 in 60; but under all conditions of surface and gradient the extent to which a horse is laden is a material consideration. The chance of an accident to a horse is greater when it is heavily laden than when lightly laden. It is necessary therefore to inquire further into the nature of the gradients of the various thoroughfares under observation in order to see if one street was more favourable than another.

Asphalte.—The gradients of the asphalte in Cheapside and the Poultry were excellent; there being but a very short length at the western end of Cheapside which was as steep as 1 in 58.

Granite.—The gradients in King William Street were for the most part excellent. In Cannon Street there were 326 ft. lineal, or about 40 per cent. of its length, of which the gradients varied from 1 in 30 to 1 in 31. Taking both granite pavements, this indifferent gradient was 22 per cent. of their entire length.

Wood.—On the wood pavements the gradients south of Arthur Street were excellent. In the vicinity of King William Statue there were various lengths, amounting to 12 per cent. of the total length of the wood, which had gradients of from 1 in 30 to 1 in 37. Moreover, in the vicinity of the statue, where the direct gradients were the worst, the pavement at several places had transverse slopes, varying from 1 in 20 to 1 in 38. Nearly the entire surface between Eastcheap and a short distance south of the statue had objectionable cross gradients.

From what has been stated as to the effect of gradient, it was not to be expected that accidents would be traceable to gradients less steep than 1 in 60. The observations do not show that accidents increased in regular proportion as the gradients became sharp, whether above or below 1 in 60; but they indicate that when the gradients were from 1 in 30 to 1 in 50 a larger proportion of accidents occurred both upon the granite and wood than elsewhere on the same lines where the gradients were better.

Thus the mean of the fifty days' observations showed that a horse might be expected to travel 103 miles before falling on the western end of Cannon Street, where the gradients were 1 in 30 and 1 in 31, assuming it to have travelled both uphill and downhill; whilst eastward in the same street, where the gradients varied from 1 in 61 to 1 in 841, it might be expected to travel 187 miles before it fell. The mean of all the granite pavements gave a distance of 132 miles before an accident happened to a horse.

It was shown that in Cannon Street accidents on the inferior gradients oftener occurred to horses going uphill than to those going downhill.

The observations it is true show an excess of accidents on the granite at some parts where the gradients were better than those just referred to; as, for example, at the western end of King William Street, by the church of St. Mary Woolnoth, which had a gradient of 1 in 54; but there the excess was probably attributable to the state of repair of the surface, in conjunction with the speed of travel in that thoroughfare, and also to its immediate proximity to the asphalte.

On the wood pavement in the vicinity of the statue, where the gradients were 1 in 30 and 1 in 37, and where the objectionable cross gradients existed, the records are mixed with those referring to adjoining lengths of roadway having gradients of from 1 in 30 to 1 in 260; but the average of the whole shows that a horse might be expected to travel in that neighbourhood 244 miles before it fell, whereas on that part of the pavement which lies between the statue and London Bridge, on which the worst gradient was 1 in 56, the distance which a horse might be expected to travel was 784 miles.

The accidents on the ligno-mineral pavement in Gracechurch Street were at the rate of 1 in 58 miles. There the gradient was 1 in 49. If any accidents may have been attributable to this gradient, it cannot alone account for the large number occurring at this spot.

The asphalte pavement was, therefore, as regards gradients, more favoured than the others. The next in order was the granite. The wood pavement was, on the whole, the least favoured.

Effect of Condition of Surface Repair.

The state of repair of the surface of a pavement affects its safety. For instance, more horses may be expected to fall on a granite pavement that has many sunken places, and the general surface of which is worn smooth, which is the condition of nearly all granite pavements when they need relaying, than on one which has an even surface and is somewhat rough to the foot, which is the condition of a *new* granite pavement.

It has already been stated that the surfaces of both the asphalte and the wood were in excellent condition, and that those of the granite were not. Cannon Street was not, however, in such a state as to lead to the belief that the accidents taking place in it were materially attributable to the state of repair; but the pavement in King William Street being under order to be renewed, was undoubtedly in such a state as may have caused some. For neither the traffic nor the gradient can have caused the excess of accidents that occurred in that portion of the street where the pavement was in the worst condition.

Had the wood pavements been in an indifferent condition of surface repair, more accidents would probably have taken place on them than actually occurred during the fifty days' observations.

As regards asphalte the case is somewhat different. Asphalte is not likely at any time so to vary in condition as to increase materially the number of accidents taking place on it. If holes show themselves of any size or depth in this material, and they be not speedily repaired, they are quickly enlarged by the traffic, and the destruction of the pavement at those spots soon follows. It will be absolutely necessary to keep at all times the surface of the asphalte comparatively smooth, and therefore the number of accidents taking place on it is not likely to be increased by condition of surface repair.

In comparing the results of the observations for general application, it must then be borne in mind, that in respect of surface repair the asphalte and the wood were more advantageously placed than the granite.

Effect of Surface Cleanliness.

The thoroughfares of the city of London are now, speaking generally, perhaps as clean as streets of so much traffic can be kept, except by washing them daily. Cleanliness has a very important influence on the slipperiness of all pavements. Its effect, however, differs materially; in some cases being favourable, in other cases unfavourable to foothold; this quality de-

pending largely on the moisture of the surface. A description of the way in which the streets were cleansed during the observations has been given in a previous part of the report (page 22).

As an example.—For safety, asphalte generally cannot be too clean; but a granite pavement when very clean may, under certain atmospheric conditions, be much more slippery than when dirty. If clean, there are occasions when the iron from the horses' shoes and from the tires of the wheels is caught by the surface of the stones, which then acquires a metallic appearance; the pavement is then most slippery. If it be not clean, the dust or dirt interposes as a medium between the surface and the horses' feet, and the slipperiness is in a certain degree prevented.

A similar metallic appearance may be noticed on asphalte in very dry and cold weather, if the roadway be kept clean; and it is observable especially at night. But this condition does not appear materially to affect the slipperiness of the asphalte, or certainly not nearly in the same degree that it does granite.

On the other hand, if granite be dirty, and the dirt be slightly damp, it is more slippery than when clean and slightly damp. Asphalte is similarly affected, but in a very much worse degree.

The safety of wood is little affected whether it be clean or not, so long as the surface is dry. If dirty, wood becomes just after rain much more slippery than at any other time; which is not the case if it be perfectly clean.

These remarks on surface cleanliness are made because many of the accidents occurring on the granite pavement during the fifty days' observations would certainly not have taken place had the pavement not been kept so clean. Similar cleanliness was beneficial to the other pavements. On the whole, the cleanliness under the circumstances to be narrated in the section which treats of the effect of weather on the surface, will be seen to have placed the granite at a disadvantage compared with the other pavements.

The Effect of Weather on the Surface.

The surfaces of all pavements are largely affected by the weather. A cold dry wind, a hot sun, a heavy or a light rain, a thick fog, or even a very moist atmosphere, causes them to be more or less slippery, according to the character of the pavement, and other conditions. Moisture plays a very important part in the safety of travelling.

For example—during a continuation of cold dry wind, with a somewhat hot sun (an atmospheric condition prevailing largely in the spring), neither asphalte nor wood is slippery, whilst granite, if it be worn smooth, which is its ordinary condition in London, and if it be clean, is in its very worst state of slipperiness. If light rains ensue the slipperiness of the granite is much reduced; the wood will then enter into its most slippery state, but for a short time only; as the mud soon begins to peel from the surface, whilst the asphalte becomes for a time almost as slippery as a pavement can be, times of frost or snow excepted, and continues so until the mud becomes nearly liquid. If the rain falls heavily the granite becomes in its safest condition; the asphalte much safer than when merely damp; and the wood approaches in safety its condition when actually dry.

Again, as soon as fine weather comes after much rain, the street dirt clings to the surface of the wood on account of that material retaining moisture; but the wood does not always become slippery whilst this process is going on. The mud in the joints of the granite retains its moisture for a long time if the atmosphere be damp, and causes that pavement for a certain time to be more slippery than when wet. Asphalte, which from its impermeability soon dries, enters again quickly into its safest state, but not until it has passed through an intermediate stage between wetness and dryness, during which it is quite as slippery as when rain first falls on it after drought; unless, indeed, the rain has fallen heavily and washed it perfectly clean.

It must therefore be understood that these conditions of slipperiness are subjected to manifold changes, according to the condition of the weather and the state of cleanliness of the surface of the pavement.

With the view of ascertaining how the number of accidents was affected by the moisture on the surface, observations on that head were recorded throughout the day and also each time an accident occurred. Owing to the many gradations between positive dryness and positive wetness, and the condition of each surface varying many times during the day, uniformity of description was not obtained in the records. Nevertheless the records admit of the accidents being arranged generally under certain classes of surface moisture, and of some general approximate results being arrived at.

It is then of importance in judging of the relative safety of the different pavements to give consideration to the state of the weather whilst the observations were in hand, in order to see whether it was such as was likely to be more favourable to one pavement than another. Indeed, without full consideration of this point all conclusions as to the relative safety of the pavements would be fallacious; the subject of the weather will, therefore, be treated more fully than it has yet been.

As regards wind. Its direction frequently shifts for short periods during the twenty-four hours; and there are, therefore, various directions recorded during one day. This was the case during the period of the observations of accidents, as will be seen by Table E. Examination shows that the wind was either from the east, north-east, or south-east during a large proportion of the time; being in fact in those directions on thirty-eight days out of the fifty, or 76 per cent. of the whole.

During the fifty days' observations there was according to the Registrar-General's returns, about 18 per cent. less than the usual proportion of rainy days taking the average of the year, and about 14 per cent. less than the average during the same months. The police returns of the number of wet days is still less, inasmuch as they only recorded the rain when it fell during the twelve hours' observations, but what is even more important is, that the quantity of rain was very noticeably less, inasmuch as it was but about 53 per cent. or little more than one-half of that which usually falls in the same time at that season of the year. Moreover, a considerable portion of it fell during the night, when the observations of accidents were discontinued. It must above all be noticed that there was an almost entire absence of days in which rain fell at intervals in small quantities, or drizzling, although such days are very frequent in London during the year.

As regards temperature, it was a trifle lower than the average of years, and the atmosphere was on but few occasions much charged with moisture. The weather was in fact in its main features, quantity of rain excepted, that which usually occurs in London in the spring; when dry winds are accompanied by a warm sun; owing to which moisture soon passes away from street surfaces.

The weather, therefore, on the whole was very favourable to asphalte; there having been a great absence of that weather which creates a damp surface and causes that material to be in its most slippery state; and was very unfavourable to granite, inasmuch as that material, if clean, during dry cold winds is in its most slippery condition. As regards wood, the absence of rain was decidedly favourable to it, although moisture does not appear to render that material relatively so slippery or to play so important a part as regards safety as it does with asphalte and granite.

Table E in the Appendix shows the accidents which took place under different conditions of surface moisture. The general results are:—

Mean of the fifty days' observations, including all those conditions of weather and surface moisture which occurred during that time.

Situation.	Distance travelled before a horse fell.
	Miles.
Granite:—	
King William Street and Cannon Street .	132
Asphalte:—	
Cheapside and Poultry	191
Wood:—	
King William Street and Gracechurch Street	330

These results have been given before, but are repeated here for facility of reference.

Separating the accidents under three heads; namely, those which occurred when the pavements were dry—those which occurred when they were merely damp, as during very slight rain and after rain had ceased, and after the streets had been watered—and those which took place either when rain was falling or whilst the surfaces were wet, the following results were obtained:—

Table showing the comparative slipperiness of the various pavements under three different conditions of surface moisture.

Days when surface of the pavements was generally dry:—

Situation.	Description of pavement.	Distance travelled before a horse fell.
		Miles.
King William Street and Cannon Street . . .	Granite	78
Cheapside and Poultry . .	Asphalte	223
King William Street and Gracechurch Street . . .	Wood	646

Days when the surface of the pavements was damp in different degrees :—

Situation.	Description of pavement.	Distance travelled before a horse fell.
		Miles.
Cheapside and Poultry . .	Asphalte	125
King William Street and Cannon Street . . .	Granite	168
King William Street and Gracechurch Street . . .	Wood	193

Days when the surface of pavements was wet :—

Situation.	Description of pavement.	Distance travelled before a horse fell.
		Miles.
Cheapside and Poultry . .	Asphalte	192
King William Street and Gracechurch Street . . .	Wood	432
King William Street and Cannon Street . . .	Granite	537

The following table groups the results in a different order :—

Table showing the degree of slipperiness of each pavement under three conditions of surface moisture, beginning in each case with that condition under which the pavement was the most slippery.

	Falls.	Distance travelled. Miles.
Asphalte :—		
1st. When pavement was damp in different degrees . . .	1 in	125
2nd. When pavement was wet .	1 in	192
3rd. When pavement was dry .	1 in	223
Granite :—		
1st. When pavement was dry .	1 in	78
2nd. When pavement was damp in different degrees . . .	1 in	168
3rd. When pavement was wet .	1 in	537
Wood :—		
1st. When pavement was damp in different degrees . . .	1 in	193
2nd. When pavement was wet .	1 in	432
3rd. When pavement was dry .	1 in	646

The following table groups the results in another order :—

Table showing the slipperiness of all the pavements under various conditions of surface moisture which occurred during the fifty days' observations, beginning with the most slippery.

Situation.	Description of pavement.	Distance travelled before a horse fell.	Condition of surface as regards moisture.
		Miles.	
King William Street and Cannon Street . .	Granite	78	Pavement dry
Cheapside and Poultry .	Asphalte	125	Pavement damp
King William Street and Cannon Street . .	Granite	168	Pavement damp
Cheapside and Poultry .	Asphalte	192	Pavement wet
King William Street and Gracechurch Street .	Wood	193	Pavement damp
Cheapside and Poultry .	Asphalte	223	Pavement dry
King William Street and Gracechurch Street .	Wood	432	Pavement wet
King William Street and Cannon Street . .	Granite	537	Pavement wet
King William Street and Gracechurch Street .	Wood	646	Pavement dry

From the foregoing summaries it appears:—

That asphalte was most slippery when merely damp, and safest when perfectly dry; that a horse might be expected to travel on the asphalte without an accident nearly twice the distance when the pavement was dry that it could do when damp; and that the difference between the safety of asphalte when wet and dry was not considerable.

That granite was most slippery when dry, and safest when wet; that a horse might be expected to travel on granite without accident nearly seven times the distance when the pavement was wet than when dry; and that the granite was about twice as safe when merely damp as when dry.

That wood was most slippery when damp, and safest when dry; that a horse might be expected to travel on the wood more than three times the distance when the pavement was dry than when damp; and that the wood was more than twice as safe when wet as when damp.

Here it will be convenient to show the difference between the slipperiness of the two wood pavements under observation.

About 1,394 ft. lineal, or 94 per cent. of the entire length of the wood, was that of the improved wood pavement. The remaining 87 ft. lineal, or 6 per cent. of the whole, was the ligno-mineral pavement.

It will be seen that altogether 380 horses fell on the improved wood pavement, and 162 on the ligno-mineral pavement. Dealing with these figures in the same manner as before, we find that a horse might be expected to travel before it met with an accident 446 miles on the improved wood pavement, and 58 miles on the ligno-mineral pavement. In other words, the improved wood was nearly eight times safer than the ligno-mineral under such conditions of weather and traffic as took place during the fifty days' observations.

The ligno-mineral pavement had a gradient of 1 in 49, which was certainly not so good as a considerable length of the other pavement, but the improved wood had 267 ft. in length with gradients varying from 1 in 30 to 1 in 37, which are very much worse for traction than 1 in 49. In addition to this, it had the disadvantage of the bad cross gradients, and it is evident, therefore, that gradient cannot account for the large proportion of falls which occurred on the ligno-mineral pavement.

The traffic on both of the pavements was much the same in character, and passed at about the same speed; and as the surfaces of both were in very nearly equally good repair, one was not more disadvantageously placed than the other in these respects.

Many omnibuses turn round on the ligno-mineral pavement to take up their station on the eastern side of Gracechurch Street, and it was at first imagined that accidents might have been attributable to that cause. On looking into the matter, it was found that the omnibuses were for the most part empty, or nearly so, and that they turned round slowly, so that accidents did not occur to their horses in any larger proportion than to the other traffic. Even if some accidents were caused by this, they would not account for the excess.

It is important to separate these accidents. If those which occurred on the ligno-mineral are eliminated, and those which occurred on the improved wood are alone used for comparison with the asphalte and granite, it will be seen (as shown in Table F in the Appendix) that a horse might have been expected to travel during the fifty days' observations 446 miles on the improved wood pavement before it met with an accident, instead of 330 miles as shown by the summaries, in which *both* woods are taken together, and that the order of slipperiness would therefore be :—

	Distance travelled before an accident occurred. Miles.
1. Granite	132
2. Asphalte	191
3. Wood	446

Concluding Remarks.

A consideration of those sections of the report in which the pavements are referred to under the various conditions that affect their slipperiness shows how wrong it would be to take the first broad results of the observations as an exact measure of the relative safety of the pavements at all times and seasons. It would not, however, be possible to substitute for the results now placed before the Commission anything in a similarly exact shape, unless observations were taken over the three classes of pavements in other seasons of the year. All that now can be done is to take the figures given by the fifty days' observations, and after studying them by the side of those modifying circumstances which have been set forth in the various sections of the report, to draw such general conclusions as may seem to be warranted.

The first thing, therefore, is to consider the effect of those conditions in which one pavement was more favourably placed than the others. Conclusions on these points have been given in the sections in which they have been separately treated of, and taking them in the order of the report, their general results are as follows :—

As regards the effect of the speed of traffic, the wood and asphalte were as nearly as possible under similar conditions. The granite, having at one place a higher speed, and the pavement there not being in so good a condition as the others, was placed in less favourable circumstances.

As regards gradient, the asphalte was the most favourably placed ; the granite the next so ; and the wood the least.

As regards surface repair, the asphalte and the wood were in equally good condition, while the granite was in a very inferior condition.

As regards cleanliness of surface, all three pavements were equal so far as the materials of which they were composed enabled them to be.

As regards weather. It was very much in favour of the asphalte ; was generally favourable to the wood ; and was very unfavourable to the granite.

Taking the whole group of conditions into account, the asphalte was the most advantageously placed ; the wood was the next so ; and the granite was the worst placed.

On the average of the whole fifty days' observations, the granite was found to be the most slippery, the asphalte the next so, and the wood the least.

Separating the accidents under three conditions of surface as regards moisture, it appears :—

That asphalte was most slippery when merely damp, and safest when dry.

That granite was most slippery when dry, and safest when wet.

That wood was most slippery when damp, and safest when dry.

That when the surface of the pavements was generally dry, granite was the most slippery, and wood the least slippery.

That when the surface of the pavements was damp in different degrees, asphalte was the most slippery, and wood the least slippery.

That when the surface of the pavements was wet, asphalte was the most slippery, and granite the least slippery.

That on the whole wood was less slippery than either asphalte or granite.

That if the observations on the ligno-mineral paving be eliminated, and the improved wood pavement alone taken for comparison, wood was on the whole less slippery than either asphalte or granite, in a marked degree, it only being inferior to granite when the pavements were wet, and the difference then between the wood and the granite being inconsiderable.

That of those accidents which are most obstructive to the traffic, as well as most injurious to the horses, asphalte had the greatest proportion, granite the next, and wood the least.

That the greatest proportion of accidents on all the pavements was to horses in vehicles drawn by three or more horses.

That had the granite been under as favourable conditions as the asphalte and the wood, the results would have been more in favour of the granite, although to what extent cannot be stated.

Finally, I beg to state that it would be desirable to make observations at a different season of the year to that in which those herein recorded were taken.

A FEW NOTES ON MINES AND MINING IN HUNGARY.

[*Continued from "Practical Magazine," No.* 9, 1873.]

THE mountains which surround Schemnitz consist chiefly of trachytic greenstone enclosing porphyry, with which are associated granite and gneiss. The argentiferous lodes occur in this formation, and it deserves to be noticed that they are identical with the metalliferous porphyry of South America, and very similar to the silver-bearing rocks of North America.

The gangue or veinstone consists of decomposed fragments of the porphyric rock, quartz, limestone, heavy spar, and iron and copper pyrites. The silver appears in this combination chiefly as silver sulphide and argentiferous galena, and, in smaller quantities, as ruby silver, and in the metallic state. It is always accompanied by gold, more so in the mines of Kremnitz than those of Schemnitz.

The silver sulphide, called by mineralogists silver glance, consists, when pure, of 87·04 per cent. of silver and 12·96 of sulphur. Ruby silver, or pyrargyrite, is a composition of 58·98 silver, 23·46 antimony, and 17·56 sulphur. The silver associated with galena is in the state of sulphide.

The first operation to which the ores as they issue from the pits are submitted is that of crushing in the stamping mills. These mills are similar to those usually employed in continental mining works. The stem or lifter is a beam of beech wood, 12 ft. to 14 ft. in length, and about 6 in. to 8 in. square, and provided at its lower end with a parallelopipedic block of hard cast-iron. The latter weighs about 1 cwt., the whole stem 3 cwt. The iron block is provided with a shank which fits into the wood, to which it is firmly attached by two iron bands pushed over the beam, and fixed there by wedges. The axle is likewise of wood 1½ ft. to 2 ft. in diameter, and possesses iron journals. The stamping beams are lifted by wooden tappets. The crushing box is formed of heavy planks, and the bottom of it is paved with quartz fragments which have been driven in with an iron ram.

The mills are partly self-feeding, partly provided with a hopper, into which the ore is thrown by little boys. The stamping operation is carried on under a constant supply of water.

There are 2,000 stampers at the present time in the Schemnitz works, each of which crushes about 8 cwt. of galena per minute. The waste of iron from the stamper-blocks is estimated to be nearly 1½ pounds for every ton of ore crushed. The stampers have a lift of 10 to 15 inches.

The crushed ore next undergoes sorting. This is done by boys and lads, who, after some practice, acquire great skill in the operation. Over the table on which the sorting is carried out, hang small iron stampers suspended by elastic springs, which serve to reduce larger lumps of ore to a suitable size, mostly to about 2 cubic inches. The smaller grain and dust are separated from the larger pieces, and each kind separately subjected to washing.

The washing, formerly conducted in tanks and troughs, is now performed in a revolving drum of about 10 ft. length and 6½ ft. diameter in the middle. The motion is slow, only eight or nine revolutions in the minute. About 200 or 250 cwt. of ore are washed in twelve hours, and only 1½ horse-power are required for setting the drum in motion. The amount of water passing through the drum in twelve hours does not exceed 400 cubic feet. The washed ore passes out from one end of the drum, and is thrown on the uppermost of four sieves, which are vertically superposed upon one another, and fixed in a framework set into vibration by a special mechanical contrivance.

The sieves are iron sheets, perforated by holes of various sizes. The holes of the topmost sheet are of $\frac{7}{12}$ in. diameter ; those of the sheet next below of $\frac{1}{3}$ in. diameter ; of the third sheet of $\frac{1}{5}$ in. ; and of the lowest of $\frac{1}{12}$ in. The whole frame vibrates six times in a minute, and its sieves yield three sorts of ores : lumps (Klauberz), three kinds of rough grainy sand (Satzvorrath), and fine powder. This last, together with the powdery portions of the stamping works, comes into the amalgamating mills (Quickmühlen) in order that its gold may there be extracted.

These mills are peculiar to the Schemnitz works. A good account of them has been given by H. Pache in an older volume of the "Annales des Mines," and a *résumé* of this has appeared in J. A. Phillips's work on gold and silver mining. For convenience' sake we will follow the latter description, adding however such notes and making such corrections as have come to our knowledge from the reports of the mining officials to the Hungarian Government.

The amalgamating vessels are hard cast-iron basins or bowls, of which there are eight, arranged in two rows, one placed about four inches higher than the other. In front of the lower row stretch seven inclined planes, having the same flooring but separated from each other by partitions 2 in. wide and 1½ in. deep. The distance between two such divisions is 18 in., and the length of the table 6 ft. 10 in., with an inclination of 15 in. between its two ends. Each of these inclined planes is completely covered over by two pieces of canvas a little wider than the platform, and slightly exceeding half its length.

The bowls are, as already stated, of cast-iron, half an inch thick in the metal, 22 in. in diameter at top, and 17½ in. at bottom, with an internal depth of 7 in. This basin is simply placed, without any special foundation, on the floor, to which it is secured by means of two iron ears. A wooden cylinder is bolted vertically in the centre of the pan, and is bound at top and bottom by iron rings, whilst at its upper extremity is an iron thimble, for the reception of the lower end of a vertical shaft. The runners, destined to revolve in the basin, are of wood ; the pivot of the spindle is so

placed as to be exactly vertical, both with regard to the bottom of the basin and the face of the wooden block forming the revolving portion of the mill. This adjustment is readily managed by means of a tripod attached to the wood at its extremities, and of which the central part fits on to the square portion of the spindle. The circumference of the wooden block is bound by two strong iron hoops, its lower face being provided with twelve blades or stirrers of thick sheet iron, driven into the wood, and projecting about half an inch, arranged as the radii of a circle. The space between the runner and the pan (the distance between which can be regulated) receives the charge of mercury, usually twenty-eight pounds. Formerly the distance was so arranged that the blades penetrated slightly beneath the surface of the mercury, but it has been ascertained that the amalgamation progresses more rapidly and with less loss of mercury when the lower edges of the iron stirrers are kept slightly above its level. The distance allowed between the circumference of the runner and the inside of the pan within which it revolves is about one-sixth of an inch, and the upper extremity of each vertical shaft is retained by the bearings. These shafts have also a coupling in some portion of their length, which enables one or more of the runners to be thrown out of action without interfering with the remainder.

The various mills are set into motion by means of two mitre wheels, one of which is attached to the axle, the other to a shaft with a pulley, around which is an endless strap bearing on the riggers of all the mill runners. The relative diameters of the mitre wheels are so calculated as to cause the runners to make twelve to fourteen revolutions per minute. Higher and lower speeds have occasionally been given to these mills, but the above number of revolutions per minute has been found to yield the most satisfactory results.

It has also been ascertained that from eight to nine mills are required for the treatment of the sands and slimes (*Schlich*) resulting from the action of every ten stampers, which amounts to about seven thousand pounds in the course of twenty-four hours.

The working of this apparatus goes on concurrently with that of the stamping works, and requires but little supervision. The slimes are discharged into a canal, from which they pass through a screen of wire gauze, by which gross impurities, as fragments of wood, &c., are separated, and then flow into a second canal, from which they pass through four small spouts into the basin-shaped cavities in the runners of the mills. The slimes now descend so as to come in contact with the mercury contained in the basins, where they are constantly agitated by the iron blades fixed in the revolving wooden blocks, and finally rising through the annular cavity between the edge of the runner and the inside of the basin, escape by a lip into the mill immediately below it. Here precisely the same action takes place as in the first, and the slimes flowing off into the canal are distributed over the inclined tables by means of apertures prepared for that purpose in the side of the first canal.

The motive force required for eight mills is one-eighth of a horse-power. The agitation of one charge of mercury is continued for a month, when the mills will be thrown out of action and the whole of the quicksilver removed. The semi-fluid amalgam is now subjected to two successive filtrations. It is first pressed out in canvas wrappers, and after this in buckskin bags. A lump of solid amalgam is thus obtained, which contains from twenty-eight to thirty-three per cent. of gold, and which is submitted to distillation in cast-iron retorts. These retorts, mostly of cylindrical shape, are connected with receivers filled with cold water, in which the mercury, volatilized by the heat, collects.

The mercury separated by filtration, and which still retains a little gold, is returned to the pans, and the mills commence their operations again. The monthly loss of mercury in an arrangement of eight mills amounts to two and a-half, and even three ounces. A single boy is sufficient for the superintending of ten or twelve of the tables. His special task is to remove, at intervals of two hours, the cloth from each table in succession, and, after having washed it in a tank prepared for the purpose, to replace it as before. In the case of ordinary ores, affording from fourteen to fifteen loths per thousand quintals (about three dwt. per ton), eight loths are extracted by the mills, and from five to six by the inclined tables, so that from one to two loths only are obtained from the slimes by smelting. The sands and slimes passing off from the tables are collected in settling pits and labyrinths, from whence they are subsequently removed for concentration, principally on shaking tables.

These tables are suspended by four chains, two at the one end (called head) shorter than the two at the other end (called tail); the latter couple of chains is attached to wooden rollers, furnished at each end with ratchet-wheels, by means of which their length may be easily regulated. A wooden axle, to which two or three cams are fixed, throws by its revolution and by means of these cams a lever forward, and through this a rod, which in its turn gives a push to the suspended table. It is obvious that the table will move forward in the direction of head to tail as long as one of the cams acts upon the lever; but as soon as the cam has been carried through the revolution of the axle beyond the lever, the table will return with a sudden jerk to its original position. Fixed to the head end of the table is a wooden board called the tongue, which, on the return of the table into its original place, strikes against a stout bar placed on purpose in front of two of the supporting pillars of the framework. The shock received by this bar imparts a series of vibrations to the table, which gradually become weaker and weaker, whilst the table is again propelled forward and pushed by the cams as just described. The position of the bar forming the stop is regulated by wedges, and the length of the rod, which imparts the forward motion of the lever to the table, can be adjusted by the use of a screw, wheel, and pinion, in such a way as to increase or diminish the throw of the table. Above the axle of each table is a wooden platform, on which are stored the slimes to be treated, and which are from thence transferred to a cistern, of which the bottom has a considerable inclination, and is provided with a semi-circular opening. Below this opening is a small spout or gutter, leading to the higher end of an inclined plane which conducts the slime to the shaking table. The slime-conducting plane consists of two parts, placed one above the other, but both inclined at the same angle, and on the upper one are arranged a number of little wooden buttons, by the arrangement of which the regularity of the flow of slime over the whole surface is easily secured. Sometimes a strainer of wire gauze is placed across the head of the lower portion of the upper end of the table, for the purpose of collecting chips or any other impurities that may have accidentally mixed with the slimes.

Two gutters run the whole length of the establishment; one used for the purpose of supplying clean water, the other for carrying off the impoverished slimes. The shaking apparatus is put into motion by water-wheels, one horse power being required to keep two tables in operation, each of which suffices to wash the slimes of four stampers.

It is easy from the above description of the shaking tables to understand their working. The slime is thrown with a shovel into the cistern and a small stream of water allowed to fall into it, which, mingling with the slime, escapes by the hole at the bottom of the cistern, and, descending in an even flow over the inclined plane, covers the entire width of the head of the table. In order to facilitate the mixture of the slimes and water, it is generally necessary to use a shovel, by which the contents of the box are occasionally stirred; and when the sands mixed with the slimes are somewhat coarse, a small wooden hoe is employed to rake the deposit on the top end of the table gently against the current.

The angle of inclination of the tables suspended by the four chains varies according to the nature of the slimes to be treated. The change is brought about by lifting or lowering the upper end, the heads of the table; the chains at the tail end are never altered. The tension of these latter chains is usually about $5\frac{1}{4}$ in., whilst for the chains at the head it is 2 in. for coarse slimes, and somewhat more for fine slimes. In like manner, the extent of the throw of the table depends on the nature of the material to be worked; for coarse slimes it may amount to $5\frac{1}{2}$ in., for fine samples 2 in. prove sufficient. The number of vibrations is so calculated as to keep the table in uninterrupted motion, without leaving it for any moment in rest; the number of throws per minute is for coarse slimes about sixteen, and for finer qualities thirty-five to forty. In such case there are, however, ten to fifteen secondary vibrations, caused by the elasticity of the bar against which the tongue falls as often as the table returns to its natural situation.

The period, during which the table is worked uninterruptedly, varies also according to the nature of the slimes; it lasts from six hours to two or three days, and during this time the deposit of enriched mud accumulates towards the head of the table to a depth of six to seven inches. As soon as this is the case, the working of the apparatus is stopped, and the deposit divided, according to richness, into three different portions, each of which is separately dealt with. But since even the richest portion is comparatively too poor to be sent directly to the smelting works, it is usually worked over again. The next best portion, the deposit from the middle of the table, is always subjected to renewed shaking; whilst the portion from the lower end is generally thrown away as valueless. The two or more portions (for the middle deposit is frequently divided into two parts) from the first table that are to undergo fresh treatment, are subjected to the enriching operation on different tables.

It was above stated that the cloth spread over the inclined tables (in front of the amalgamating bowls) is rinsed by a boy in

a tank of water; the material accumulating in consequence of the repeated washings has to be treated for concentrating its gold and silver; and the operations for that purpose are carried out successively in two tray-shaped vessels, called in German Lütte and Scheidetrog.

The first-named vessel is an inclined trough, about twelve feet long, two feet broad, and nearly one foot deep, with an inclination of about thirty inches on its length. The higher portion of the plank which forms the bottom has cut in its surface small rifles, running in zigzag, and forming with the upright sides of the trough an angle of forty-five degrees. At some little distance from the upper end of the box is a wooden screw, of less height than the sides of the trough, behind which a current of water enters through a tap, and which, as it flows evenly over the edge of the screw, spreads with regular uniformity over the gold-bearing slime placed in front of the screen. The workman stands beside the box, before which there are three longitudinal receptacles for the collecting of the products of the operation.

The operation is carried on very similarly to that of a so-called sleeping table. The finely-powdered ore is introduced in small portions with a shovel, some water is permitted to flow over its surface in order to distribute the slime in the trough, and then a continuous stream of water is allowed to flow through the box, whilst, at the same time, the workman quietly sweeps with a brush the surface of the mud upwards, *i.e.*, in a direction contrary to the current.

The products of this operation are also classified into three portions. The first, a rather coarse slime, contains gold, silver, galena, and iron pyrites; the second is similarly composed, but is of a much finer grain; the third is very concentrated and specially rich in gold. The first two portions are treated over again in the *Goldlütte* before they go to the smelting furnaces; but the third is transferred, for the sake of renewed washing, to the *Scheidetrog*.

This little instrument is cut out of a single piece of wood, elm being usually employed for this. The workman keeps it under the lower end of the previously described Lütte, and sweeps into it by means of a brush, and assisted by the flow of a little water, the concentrated auriferous sands. Having collected the material on the Scheidetrog, the workman commences to shake the little hand-trough in a manner similar to the motion of the shaking table, knocking at each vibration the top end of the little instruments against his leg. After operating for a while in this way, the trough is held under a thin stream of water, allowing the latter to flow from the upper end towards the lower, when the gold will make its first appearance as a pale yellow streak. The grains thus washed down in the course of a day are collected, washed again in the same manner, and finally amalgamated.

The amalgam is worked up, as usual, by filtration, and ultimately distillation.

We have now to look after those portions of ore which were separated at the stamping works and the shaking tables. Here, too, we will follow Mr. Phillips's description, since it is based upon an account which evidently had been derived from the same source as our own information, viz., the official reports of the mining authorities. Though the account referred to is of somewhat older date, yet, since there has been no essential change in the mode of working the furnaces, the description is still very good.

The ores intended for the smelting works are divided, according to their richness, into three classes:—

(*a.*) Those containing less than 3 loths [1] per zentner.[2]
(*b.*) Those possessing 3 to 5 loths per zentner.
(*c.*) Those having more than 5 loths per zentner.

This classification enables the operations at the smelting works to be conveniently regulated, as the matts obtained from the poorer varieties are after roasting smelted with those containing a larger amount of silver, and a matt is thus produced, which, after being in its turn subjected to several successive roastings, is again smelted with still richer ores.

The various operations at the smelting works succeed each other in the following order:—

I. First fusion (Roharbeit).—The charge consists of poor ores of the average yield of 1 loth of silver per zentner (10 oz. per ton). Slags from third fusion, with limestone, serve as flux. The product of this operation is a crude matt (Rohblech), containing from 3 to 4 loths of silver per zentner, which after repeated roastings is fused in the second operation. The resulting slags are thrown away.

II. Second Fusion (Reich-Roharbeit).—The charge is made up of ores of an average produce of 2½ loths of silver per zentner, and roasted matt from first fusion, slags from third fusion, and limestone form the flux. The yield of this operation is a rich crude matt, containing from 8 to 10 loths of silver per zentner; this matt passes after roasting into the third process. Here too the produced slags are of no value.

III. Third Fusion (Frischarbeit).—The charge is prepared of rich ores, roasted matts from second and third fusion, and limestone. The tapping pan is supplied with metallic lead, so as to incorporate this with the precious metals issuing from the furnace. The result of this third operation is a gold and silver-bearing lead, a rich matt which is roasted and re-smelted, and slags which serve as flux in fusions I. and II.

IV. The argentiferous and auriferous lead from the tapping pan is subjected to cupellation.

I. The furnace for crude smelting (Hohofen) is about 18 ft. high, and receives its blast through two tuyères, supplied with air either by bellows moved by water power, or from a blowing-machine formed of an oblong box provided with the necessary valves, in which a piston is made to traverse. The width of this furnace is nearly 3 ft., and its depth at the tuyères a little more than 3 ft., whilst the back wall slopes in such a way that at the top, or charging place, the internal depth is 4½ ft. Over the top of this furnace arched flues or chambers are constructed for the purpose of collecting any fine particles of ore that may be driven over by the blast, and which are occasionally removed through openings closed by iron doors. The tuyères are placed exactly in the angles, and their direction is so adjusted that the blasts from them cross each other at a distance of about 2 ft. from the back wall of the furnace. These tuyères are made of wrought iron, and project about 3 in. into the furnace, the nozzles being covered with refractory clay to protect them against the action of the fuel and slags. The tuyères have a very trifling inclination, and one of them is placed somewhat higher than the other, the lower tuyère being situated about 2 ft. above the top of the breast stone. The well formed in the bottom of the furnace for the reception of the fused matts communicates with a breast pan, on each side of which is a tapping hole leading to two pans sunk in the floor of the establishment. The bottom of the furnace and lining of the breast pan are composed of brasque, which, after having been well rammed in by proper beaters, is subsequently cut out into the required form. The material operated on chiefly consists of pyrites and stamped silver ores of very low produce, to which are occasionally added some low quality cobbed ores. These are charged in the following proportions:—Stamped pyrites ore, about 70 parts; low class silver ore (*a*), about 25 parts; poor cobbed ore, 5 parts. This mixture is so composed that its average yield of silver should be something about 1 loth per zentner, or 10 oz. per ton. The gangue being chiefly siliceous and argillaceous is exceedingly difficult to fuse, and consequently demands a large proportion of flux, particularly in the first operation; in the subsequent processes the fusion is greatly assisted through the addition of roasted matts. The mixture consists of about 120 zentners of ore, the same quantity of slags from the third operation, and from 20 to 30 zentners of limestone. The ores, fluxes, and charcoal are thrown into the furnace from an upper floor, and the matts collect in the well at the bottom. The slags flow off in a constant stream over the edge of the breast pan, and are thence taken away as being of no value.

As soon as the well and breast pan have become full of fused matts they are tapped off into a float on the level of the floor, and usually contain from three to four loths of silver per zentner, or 30 to 40 oz. per ton. The furnace is kept in fire for about a month, when it is blown out for repairs, and during that period smelts about 130 tons of ore. Four men are employed at each furnace, and are paid in accordance with the amount of ore smelted. The crude matt is broken, and, after undergoing three successive roastings in heaps, is treated in operation II. For the purpose of being roasted, the matt is laid, in pieces of about the size of the fist, on a layer of wood, a little charcoal being mixed with the broken matt. Each roasting occupies from six to ten days.

II. The operation of the *Reich-Roharbeit* is performed in a furnace similar to the *Hohofen*, but smaller (called Halbhohofen). This furnace has only one tuyère. Sometimes the *Hohofen* is employed for this second process, but only when new, before its internal dimensions have become too much enlarged by the erosive action of the fused matts and slags. The charge is made up of poor washed silver ores (*a*) containing from 2 to 3 loths of silver per zentner, of some cobbed ore of about the same yield, and a small quantity of pyritous slimes, so that the average produce may be about 2 loths per zentner, that is, 25 oz. per ton. The proportions of these substances in the charge are approximately: Washed silver ore about 70 parts, cobbed ore 20 parts, pyritous slimes 10 parts. To every 100 zentners of this mixture are added from 40 to 50 of roasted

[1] 1 loth = 271 grains avoirdupois.
[2] 1 zentner = 123·8 pounds avoirdupois.

crude matt, from 50 to 60 zentners of slags from operation III., and 15 to 20 zentners of limestone. The matt produced by the fusion of this mixture contains from 8 to 10 loths of silver per zentner, or from 81 to 102 oz. per ton, whilst the slags are thrown aside as useless, unless there should not be a sufficient amount on hand from process III. to serve as flux, in which case a portion of them may be reserved for that purpose. This furnace burns out in 15 days, and in that time smelts about 40 tons of ore, together with a due proportion of slag and roasted matt. The fused sulphides obtained by this operation are roasted in precisely the same way as the matts from the first fusion, and then form one of the admixtures of the charge in the next process.

III. This fusion, the *Frischarbeit*, is conducted in the same furnace as the previous one, and the ore worked during a campaign, extending over a week, is about 16 tons. The mixture operated on consists of schlichs and the richest cobbed ore in the following proportions: Schlich about 40 parts, cobbed ore 60 parts. To every 100 zentners of this mixture are added from 30 to 40 zentners of roasted matt from a previous III. fusion, from 20 to 25 zentners of that from II. fusion, and about the same amount of limestone. From 4 to 6 zentners of lead, according to the richness of the ores, are charged into the float in the course of each shift of eight hours. The matt from the furnace is tapped into the float on the top of the metallic lead, and well stirred, in order that the largest possible amount of the gold and silver contained in the fused sulphides may be made to combine with that metal. From its greater specific gravity the lead collects at the bottom of the pan, whilst the lighter matt floats on the surface, whence it is removed in the form of flat cakes in proportion as it cools. As soon as the whole of the matt has been taken off and the lead begins to appear the furnace is again tapped, in order that the metal may not become oxidized from exposure to the air, and in this way an additional quantity of the gold and silver is taken up by the lead at each successive tapping. The whole of the lead is not introduced into the float at the commencement of the operation, but at different periods during the progress of the shift of eight hours, at the expiration of which time the enriched lead is ladled out into moulds, and the next tapping is made into the float on the other side of the breast pan.

The amount of silver and gold present in the lead thus obtained obviously depends on the richness of the ores treated, but usually varies from 40 to 60 loths per zentner, or 408 to 613 oz. per ton. The matts from this fusion contain about 14 loths of silver per zentner, or 143 oz. per ton; and, after being repeatedly roasted in small heaps, are added to the charge in a subsequent operation. The slags contain about ¼ of a loth of silver per zentner, or 2½ oz. per ton, and are employed as a flux in operations I. and II. The copper contained in the ore continues to accumulate in the matts until a regulus possessing from 30 to 40 per cent. metal is obtained, when it is removed for the purpose of being subjected to a special treatment for that metal.

IV. The last of the fusing operations is the cupellation of the rich lead. This is effected in a large circular cupelling furnace, with a marl bottom and a movable iron dome.

To be continued.

THE MANUFACTURE OF PAPER HANGINGS.

By MM. Desfosse and Karth.[1]

THE manufacture of paper hangings, though by its origin belonging to the seventeenth century, may be fairly classed among the creations of the nineteenth. The few attempts, more or less happy, undertaken by the Lebretons about 1680, and by the dynasty of François, at Rouen, from 1620 to 1750, can scarcely constitute a regular industry. The true era of paper hangings only starts from the time of Reveillon, at Aubert, and still more especially from the time of M. Zuber, of Rixheim. Like most other contemporary industries, this art was directly based upon falsification.

The dominating idea in the minds of the François of Rouen, who, as their first workmanship bears date from 1620 to 1630, may be considered the actual inventors, was to imitate the woven tapestry, with which walls were then adorned; this material was so costly that a good imitation could not but enrich the inventor; consequently, the François prospered for more than fifty years. The Rouen workmen had a speciality in velvet papers made with wool-powder, which was spread by means of a sieve upon a newly made paper, which had been sufficiently damped with oil to ensure the adhesion of the wool; they attained the art, so say the authors of the day, of reproducing the Flanders foliage, and even the beautiful figures of the Gobelin and Arbusson tapestries. The only reproach they acknowledged was a dread of dampness and an inability to fold their goods, which, for purposes of transport, had to be rolled round huge wooden cylinders. The Lebretons did not go into the figure trade, but contented themselves with marbling the papers, with which the binders then bound their books: and for their contemporaries it was a subject of vast admiration to note with what skill "they blended the delicate threads of gold and silver with the coloured veins and waves of the paper." Before the abolition of the guilds the manufacturers of paper-hangings called themselves "master paper-stainers." One of the oldest ways of decorating paper was to cover blocks or plates with representations of flowers stencilled on them with some uniform colour; then on this ground of colour the sheet of paper was pressed, and the sheet was coloured uniformly, only the flowers, which had been stencilled out from the wood, were left in white. This was in the last years of the eighteenth century, and at the moment when the manufacture of stained paper was taking such rapid strides that they applied colour on the relief of the blocks or plates, and imitating the processes of printing, produced coloured ornaments; but they were still obliged to repair by hand, and complete what the blocks had left defective. The great obstacle to the development of this manufacture was the restricted form of the sheets of paper, still at that period made in frames shaken with the hand. It was necessary after each sheet was printed to fasten it end on end to twenty-three other sheets, to form what they still call a roll, and which now, thanks to endless paper, is obtained in a single piece. The invention of endless paper, considerably reducing the cost of the prime material and singularly facilitating the work, gave the industry we are now discussing a rapid impulse, and at present it has become one of the most important branches of French trade, whether we consider the common paper manufactured by machinery in the provinces, or the papers *de luxe* made by hand, specially at Paris.

In 1810 Jacquement, successor to Reveillon, was the single manufacturer in this town, he principally produced papers ornamented with exotic flowers, copied from the Jardin des Plantes, painted with very little tone, and without that natural appearance which at present they are able to give them; and yet, as the competition was almost nil, the returns of the manufacturers were very considerable.

A little Mâcon manufacturer, M. Joseph Dufour, established himself in Paris, and engaged as his designer M. Mader, an artist of great talent, who knew how to ally grace and distinctness of composition with an economy in colours which no other house was able to obtain. He was especially famous for his imitations of architectural ornaments in the Greek style, then all the vogue. This was the epoch of ornamented chimnies and draped doors, of imitation tapestries for beds, and of figured grey hangings. One of these, representing Psyche, passed for a long time as a masterpiece in this line. In 1823 M. Mader was first established, and gave himself up to the production of decorative panels, abstaining from wall papers in rolls. Dying, he left his business to his widow, who found in M. Dauptain a formidable rival. The fashion had changed, and after 1830 the Greek, which had given place by turns to the Etruscan, the Egyptian, and the Moorish, disappeared under the Gothic and that rage for the renaissance which invaded all the arts.

The two *expositions* of 1851 and 1855 showed the truly surprising results that the trade of paper-hangings had attained. We remember the success obtained by the "Orgy of Couture," composed expressly for M. Desfossé by the great flower decorator, Müller, and the carpet in fifty-five wools by the same painter, and executed in the same establishment.

These beautiful papers had the great fault of being too costly —above all to the manufacturers; but they demonstrated to what a point the art they practise has attained, and what the makers could do if the taste of the public would only encourage them.

We are going to follow the steps through which the white paper passes before it is delivered to the consumers, covered with ornaments, flowers, figures, gilding, and different imitations of stuffs, marbles, and woods. The paper used is of several qualities, classed as grey, ordinary white, and fine white, the price of which varies from 60 cents the kilogramme to 1 fr. 60 c. It generally comes from the paper factories of the Vosges and the Somme; the breadth most frequently employed is that of

[1] Translated from "Les Grandes Usines," by M. Turgan.

30 centimetres. Some exceptional kinds are as wide as 1 metre 50 centimetres; the length of the rolls is from 8·50 to 8·75 metres. The impression should be made upon 8 metres, and always covers 4 square metres of the side of a wall. This measure dates from the time when twenty-four sheets of hand-made paper were stuck together to form a roll; the custom has remained unaltered, and to-day the roll is still the standard by which they calculate to determine the papering of an apartment.

The colours used to ornament these papers are impasted in a vehicle made of animal glue, composed of shreddings of rabbit skins or old harness leather; they use vegetable glue made from amylum or starch, to prepare the colours before imitating woods, and for the impression of the woodcuts.

The colours employed are almost all supplied by the Paris manufacturers, and whether dry or in the form of paste, are faced, in spite of the lac, that is to say, are put upon the paper as oil-colours are upon canvas, so as to form a surface, not like the colours printed upon stuffs, which penetrate into the fabric itself and colour it by dyeing.

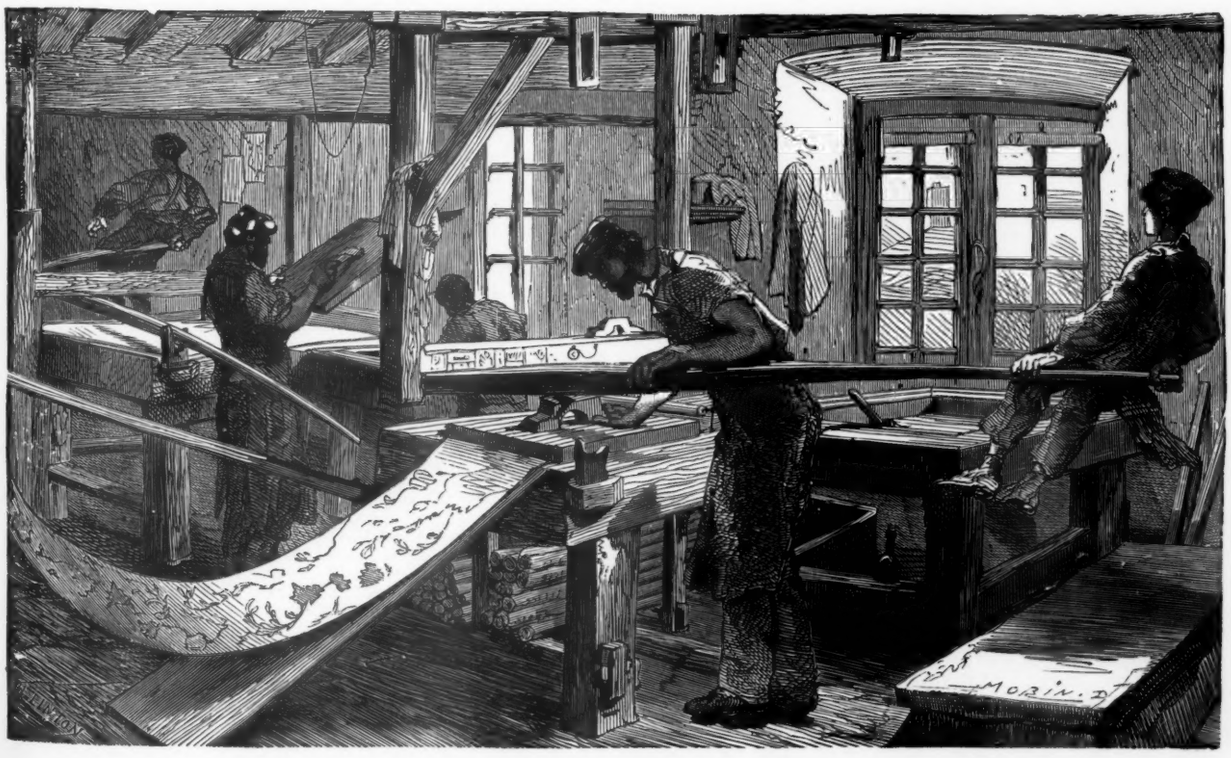
The base of all the ordinary tints is whiting or the common carbonate of lime, known to all the world. The other substances most often employed are the *blanc fixe*, invented by M. Dauptain, carbonate of baryta dissolved by chlorhydric acid and precipitated by sulphuric acid. This white does not grow yellow like the preceding; glaze paste, aluminous lime white; ochres of every shade; yellows made with chrome, lac yellow, and yellow oak. The greens are sometimes a mixture of chrome yellow and Prussian blue, sometimes Schweinfurt green, made with verdigris and arsenic; sometimes a green from ultramarine. The blues are Prussian blues or ultramarine. The reds are lacs, either from woods or from cochineal. The blacks are German black or bone black. To apply these colours to the paper they use brushes or blocks—the blocks resemble those we have described elsewhere when we treated of calico-printing; they are formed of three layers of wood, with the fibres crossing alternately, so as to avoid all warping, and fixed by a glue called cheese-glue, because it is made with cheese *à la pie*. The two first layers are of pine, the last, which is to be engraved, of pear-wood. The designer draws each tint, after models furnished by some skilful artist, upon the wood, and the engraver, using the burin and the gauge, hollows out very deeply all the parts that are not to take the colour. The fixed edges are faced with slips of brass, and might be easily made in electros, like the designs for shawls. On the other side the block has a long strap handle, by which it is moved. The blocks are very huge, for it requires about eighteen lengths to cover an entire roll; pieces of wood of such dimensions (sometimes 85 centimetres by 70 to 85) cannot be easily handled by women—thus the entire work is executed by men. The coloured ornaments are not directly printed upon the paper in the state at which it arrives at the workshops; it is first necessary to spread upon it a coat of equal and smooth colour, and this they call the *ground*. All the stained papers, even the white, are thus grounded. They spread the roll of paper upon a table some 9 metres long; one of the ends is held by a fixed vice, the other by a moveable vice, which is gently balanced by a weight, so as to stretch the paper and prevent it going into folds when it has imbibed the colours. Two workmen and an assistant execute this process, which requires a rapid speed. The first workman spreads the colour upon the paper; the apprentice, armed with two long square brushes, spreads it out as best he can, and behind him the second workman, brandishing two enormous round brushes with long hairs, equalizes the paste, which during the work has a tendency to collect together.

As soon as the grounding is done, they speedily hang the rolls upon a stick at right angles to the end of a perch, where it remains suspended on two drying rods. In certain qualities of a very high price the ground is put on in several coats; but it is not sufficient to have coloured the paper in an uniform tint. Fashion does not care to accept the dull and tarnished appearance that this process alone would give it, but demands paper polished and satined, and this can be obtained by three different methods; the first is *satining*, which is executed by a somewhat barbarous process, by rubbing the ground of the paper with a brush fixed at the end of a moveable lever, and attached by hinge joints to the ceiling of the workshop; the *satiner* spreads his roll out gradually over a marble slab, peppers it with Venetian talc-powder, and by a backward and forward movement rubs away with his brush until the surface glitters again. It is evident that a ground two coats deep, will yield a much finer satin than one. Perhaps it would be possible to execute this work which seems to have nothing artistic about it, by mechanical means. Two other polishing processes are employed, whether for the ground itself, or for the paper when it is all but completely manufactured. One, also in English called *satining* (but in French *lissage*, as distinct from satining), used especially for marbles and imitations of Persian calicoes, is executed by polishing the paper with a hard stone, simple flint or agate, fixed at the end of a counter-weighted rod, and worked in a pear-wood groove. To give more brilliancy still, they use wax soap, either as a mixture in the paste, or to be rubbed gently on the paper in the same way as a polisher rubs his furniture. The third process, which is simply varnishing, can be employed only upon glazed papers, for without this precaution the varnish would penetrate into the paper and destroy it. All these operations executed with the hand, and generally with clumsy wooden tools, yield a most picturesque effect. Contrary to almost all our present industries based upon mechanical labour, the workman here goes for everything; thus the paper-painters, by their quick and intelligent work, the rapidity of their movements, their careless and lively air, remind us of house-painters; this resemblance is still more striking if we consider the workmen whose duty it is to print upon the grounded papers, or on the grounds to imitate wood and marble.

Nothing can be stranger or more unexpected than the appearance of a printing shop; on the drying rolls hang the rods which have already undergone two or three colorations; these long sheets falling from the ceiling render the natural gloom of the place still more sombre, while round the windows the workmen, and more especially their apprentices, are bustling excitedly about. Close to the windows is placed a square oak bucket, the cavity of which is rendered water-tight by pitched joints or zinc fastenings. This bucket is filled with water, and is covered by a frame containing a piece of stretched calfskin, which lightly compresses the surface of the liquid, and thus acquires a kind of elasticity. Upon the leather, sometimes replaced by strong canvas soaked with linseed oil, they spread a woollen cloth which acts as a pallet, and on which the colours are spread. This apparatus is raised upon a trestle to the height of the printing table; the table is strongly constructed, and is surmounted by a horizontal beam, fastened to the ceiling by two baulks, under which they can securely rest the end of a wooden lever about 3 metres long. The printer spreads out a roll, which he holds by means of a rod fastened to the free end of the table. During this time the apprentice with a big brush prepares the pallet, upon which with great care and uniformity he presses the block, which he then passes to the printer; the latter inspects it to see that it is sufficiently coated, and then, leaning it carefully against certain starting pegs, applies it to the paper.

There is no question here, as in calico printing, of a stuff that easily absorbs the liquid in contact; on the contrary, paper is a rebellious substance, which, so far as it may, refuses to receive the colour at all. To achieve the printing, therefore, it is necessary to apply a heavy pressure to the block; and this pressure is still executed by a manœuvre which at first sight is somewhat astounding. On the block the workman places a beam, on the beam he rests the lever, the end of which is jammed under the cross-bar; at this moment he gives an agreed upon sign, and the apprentice leaps upwards, and seats himself upon the other end of the long wooden lever, and by his weight determines a pressure, which he often repeats several times. Descending from his perch, the apprentice sets himself quickly to spreading a new coat of colour upon the pallet; the printer rests his lever on a cross-peg, fastened to a corner of the table, and looks to see how he has succeeded. In papers the design of which is but little complicated, and for tints that are easily used, the work is extremely rapid, and success almost certain; but in regard to colours that have to go one above the other, or to tints rebellious as to impression, the difficulty sometimes becomes very great, especially for large surfaces. In these cases it is necessary to repair with a pencil the defects left in the printing, and sometimes to erase with a little movable roller the grain of the colour which without this precaution would not receive the following impressions. The successive applications of the blocks can be varied to infinity, and give as many colours and dispositions as we can imagine; only the price of the workmanship is naturally increased with the number of times the roll passes over the table. They have sought to lessen the number of these passages by using a single block to print several colours; if blue is required in certain parts, red in others, green a little further on, they arrange these colours on the pallet in the order and direction in which the block ought to receive them; pegs placed on the border of the frame serve as starting points, and indicate to the printer where he should place his block. Another arrangement called *emboîtage*, or mortising, allows them to double the colours by engraving, for instance, all the blue at one end of the block and the red at the other; in printing, the red enters the blue, fixed by the preceding impression, and the blue is left on the paper for the following stroke. The only inconvenience about this process is that they lose a half-impression of the block at either end of every roll; but it is extremely appropriate to designs where little flowers are repeated, and for

GROUNDING.



PRINTING.

borders the design of which is uniform. At the time when fashion demanded large landscapes and chimney-pieces in the form of pictures, on which either the sea or sky was figured, M. Spörlin of Vienna, and MM. Zuber of Rixheim, invented a process which was a great success about the year 1824. On the pallet cloth they arranged colours starting from azure and graduating to orange, or going from greys to greens more or less pronounced; with these tints, termed *irisées*, after the rainbow, as a ground, they impregnated their blocks, and thus transferred their sky or their water on to paper.

For some time past they have been successful in employing the roller either with the designs in relief, as in typography, or with the designs cut in, that is to say, in copperplate, as in calico printing. Other rollers engraved in relief afford only very imperfect results, and are only able to print a very limited number of colours; but they have the great advantage of speed and economy. As to copperplate, we can, with its assistance, obtain a certain number of combinations which, alternated with the other processes, yield very good effects. Thus they often prepare grounds of very delicate design, on which, with the ordinary blocks, they afterwards print flowers and ornaments. With the copperplate process they also make transverse rays; and, combining these with longitudinal rays, traced by a machine we shall describe lower down, they produce those Scotch tartan designs which even at present are very fashionable for the decoration of *cabinets de toilette*. The machine used in this copperplate printing is a simplification of the great calico presses; the roller is of engraved brass; the colour is mixed with wheat-starch; by deepening the designs more or less we can obtain what they call camaieu, with tint over tint, varying from clear to deep, according as the thickness of the colour-holder is increased.

In tracing the longitudinal lines they employ a process very similar to that we have described in our account of M. Dollfus's works; the theory is the same, only the form of the ruler is different; instead of having several reservoirs of colour each managed by a workman, they use a large brass triangular bucket divided into compartments, the bottom of which is pierced with narrow tubes, through which the metal flows and spreads itself upon the paper; they are able to give much variety to the colours and arrangements in the same bucket. By filling certain compartments, and stopping up the tubes of the others with wax, they printed the rays only upon certain determined places, the other portions remaining white. This process is executed by rolling the paper round a cylinder above the roll, and by passing the end of the sheet under the instrument, and after having fastened this extremity between two rods, drawn by an endless cord, making the paper unroll over a table of the same length as itself. In this way the paper, once softened with colour, can neither warp nor become contorted, and, as soon as it arrives at the end of the table, an apprentice rapidly picks it up on the two rods and hangs it on a drying-stick. In the same way tracings, *moirés*, and all the little copperplate designs are only used to complicate the original ground. The ruler for rays is never employed to make a paper immediately saleable. With MM. Desfossé and Karth it is generally only a preparatory instrument, the products of which are afterwards finished by either block-printing or copper-plates, gilding, or other ornamentation.

It has long been the fashion, and it is desirable that it should so continue, to make large panels with frames, representing either fanciful landscapes, hunting-scenes, or other ornaments, as paper-hangings. This variety of the work, which was really the origin of the industry, is, when it is successfully modelled, certainly that which yields the best effect. It is, however, evident, when these panels represent gross imitations of well-known pictures, or ridiculous interpretations of warlike episodes, that a simple grey paper was infinitely preferable. But if, on the contrary, they are beautiful panels of hunting pictures, as we may see at the Angoulême buffet, for example, no wall-paper, however rich it may be, has the charm of these really artistic hangings. We truly regret that this style has been so discredited by rude chimney-pieces and the grotesque daubs covering café walls, as to prevent the manufacturers from giving themselves heartily to grand productions, which, if they were only plentifully reproduced, would naturally be much diminished in price. We say for this art what some time back we said about the Arbusson tapestry—that the buildings for which they are to-day intended have no resemblance to the buildings of our forefathers—that our walls should not be decorated with niggardly hangings which would narrow and straiten their full proportions.

At MM. Desfossé's works we have seen many happy reproductions copied from M. Müller's designs; some applied to panels glazed white beforehand, others made in breadths of two or three to the roll, and almost always retouched with the brush. For these after-touches much reproach has been cast at the paper-stainers, but this, according to us, is a great error, for we ought never to consider the workmen in this industry as simple manual labourers. For them the blocks, the combs of metal and leather, the sponges, the brushes, are rather varieties of pencils than instruments that would act regularly and mechanically whatever hand employed them. In imitations of marbles and woods especially, the workman ought to be endued with the sentiment of colour and design; it is for him to render himself ingenious so as to best utilize the instruments he employs, so as to best modify them in the application of colour; even when he is concerned with rollers and machines, he still has in hand a work that is absolutely artistic. Hanging up in the drying-rooms, we have seen masterpieces well able to deceive any eyes, representing marbles and the grained roots of trees. Sometimes they consider this wood or marble simply as a ground, to be adorned still further with decorations and designs, but this, according to our thinking, is always in false taste.

Wall-paper, being before all else an art of falsification, should never give the lie to its first destination. Thus one of the most profitable of its branches is the exact imitation of stuffs, and even of their floss. It is true that weavers and paper-printers to-day mutually supply each other with much, in mutually borrowing much from each in the way of designs and arrangements. The stuffs most often imitated are Persian calicoes and velvets; and indeed it is an extremely happy idea to have the same design upon the walls as paper, and hanging over windows and doors as curtains. The imitations of Persian calicoes are printed and glazed as we have shown above; and velvet-papers are still made by the same process as that invented by the Lefrançois at Rouen—always by the employment of a kind of sticky varnish (*vernis mordant*—the same as that used for fixing prints), composed of linseed oil, boiled or half-boiled, white lead, and of a dryer with a base of litharge. They ground the paper by using this varnish instead of colour, spread the paper on a long table, where, when half dried, it assumes an adhesive tendency which retains and glues the little fragments of wool-powder that are scattered over its surface; when it is sufficiently sticky they deposit it at the bottom of a long wooden box, and that box-bottom is made of leather, or of a very close canvas, painted thick with a composition that renders it impermeable to the dust; this canvas should be tightly stretched after the manner of a drum-top; the paper, when deposited on it, is fixed with rods, then with a sieve hafted with a wooden handle, they scatter the wool-powder over the varnish, equalizing it as much as possible; next by turning a crank a whole series of spattles are put in motion, which, striking alternately and regularly below the canvas, cause it to vibrate, and so, in a wonderfully regular fashion, spread out the whole of the wool-powder. The roll is carried to the drying-room, and at the end of two days the wool held by the drying of the varnish is found to be firmly fixed. They are not content with this truly beautiful imitation of velvets, but have varied the combinations and multiplied the effects, sometimes in a very happy manner. Thus they re-impress it with ornaments either in colours or in paste, or with varnish, which they again cover with coloured wool; they have also sought to imitate Pekins, reps and damask, and the effect obtained is surprisingly exact. Over the parts he wishes to preserve in velvet the workman places large sheets of cardboard, leaving free those on which satin is to be imitated, then, simply passing a brush over the woolly fibres, he smooths them and gives them a shining, silky lustre, which would deceive the most experienced eyes.

A new process permits them to design dead ornaments or flowers upon velvet papers. The machine with which they obtain the appearance of Utrecht velvet is a press composed of four uprights, on which a platen instrument works up and down, the upper part of the instrument being heated by a circulation of gas, and the lower face fitted with copper stamps in relief. The platen is worked by a large vice which turns upon the impulsion of a ball-weighted balance—the relief-stamper machine on a grander scale. So as to render the effect of stamping sharper and better defined, they place under the paper they are going to strike a piece of cardboard which has several times been submitted to the shock of the press, and forms a kind of matrix. By this machine we have seen some very beautiful patterns stamped out, either simply dead or gilded. In gilding they powder the ornament they wish to enrich with resin, apply gold or brass in leaves, pass it under the warm platin, the resin melts, and, thanks to the pressure, the metal is fixed in a most solid manner. The ball-balances are used to apply gold or false gold to papers that have not even been velveted.

This gilding is much more solid and more beautiful than the other, but its price is necessarily much higher. The ordinary gilding is put on by impressing with a common block first glue and then varnish, which in a few hours becomes properly adhesive; when it is thought to be sticky enough, the workman covers it with brass leaf, which he presses down lightly with a paper roller; then he puts the roll in a drying-room for two or three days. When the roll is thoroughly dried, and firmly re-

tains the metal, girls, by means of a brush with long hairs, rub away all the parts of the false gold which have not adhered. These fragments are collected, pulverized, and passed through a sieve to be utilized for a third gilding process. This process consists in printing a mordant on the parts they wish to cover with metal, and quickly passing the roll through a kind of drum full of brass powder; the false gold adheres to the sticky parts, and when sufficiently dried can be either left dead or burnished. We can scarcely imagine the varieties of different combinations that can be attained by velveting, satining, re-dressing (the reapplication of colours on velvets), striking and gilding. They have attained such skill in their workmanship, that not only are they able to imitate all fabrics, but they have in their turn created a large number of actual cloths, which it would extremely puzzle the silk or wool weaver to imitate again. Many of these are sold at as high a price as fifteen francs the roll, and are well worth the money.

It is not the manufacturers only who determine the creation of these beautiful designs and compositions; having no direct relations with the public, they receive the greater part of their orders from various establishments in Paris, who generally reserve all the rights in them. These business men, who are to the true producers what the upholsterers are to the actual weavers of stuffs for furniture and hangings, receive from their clients elaborate instructions, which they send to be interpreted into shape to the factories with which they are connected. MM. Dulnat, successor to Barbedienne, and Maigret Brothers, are the intermediaries most justly in vogue, and they compose and cause to be executed designs and compositions, their rights and property in which they vigorously defend before all tribunals. To the paper-hanging trade they render great services in directing it according to the architectural requirements which they are called upon to satisfy, and in superintending the hanging of their own goods. This last operation becomes more and more difficult, and more and more important, on account of the variety of joinings, the multiplicity of borders, mouldings and rods, the profuseness of which is hurtful rather than agreeable when they are not thoroughly well arranged.

THE NATIVE IRON FURNACES OF MALABAR AND THEIR PRODUCE.

ALTHOUGH in point of number and weight of produce the furnaces on the Malabar side of the Western Ghauts cannot be compared to those which have made Salem in the Carnatic so celebrated for its wootz-steel, they are of sufficient importance and supply a sufficiently large district to merit notice; and that they have not received it before now is probably to be attributed to the very dense, and to Europeans dangerous from its fever tendencies, jungle, in which Nellumboor, the chief seat of the manufacture, lies. Merely premising that the statements in the following article are entirely the result of personal observation and practical experience, I proceed to the details.

Probably it will be better to describe first of all the materials used, then the furnace in which they are smelted, and ultimately the produce itself. The ore is a black magnetic oxide, which runs sometimes as a species of lode through the laterite, which is here in most places the covering of the trap rock, and at others is found—but this is probably the result of disintegration—as a species of sand, interspersed with nodules of the size of a pigeon's egg along the banks of the rivers or in the nullahs (watercourses) down which the monsoon torrents find their way to the low country. In no instance is it found on the plains except along the river sides, whither it has clearly been carried by the flood waters. For use in their furnaces the natives employ only the sandy portions, or reduce, by pounding, the larger ones to the size of very fine gravel; and this preference for the fine ore goes to prove that the action, as will be pointed out hereafter, of their furnaces is quite different from that of our own blast furnaces, in which, if we are accurately informed, *sand* ore by itself has not hitherto been successfully smelted. This sand, then, is collected from the hill sides and nullahs, and carried, generally by women and children, in small baskets on their heads to the sites of the furnaces; and it is somewhat a contrast to see a gang of these people thus laden passing along the narrow raised foot-paths which lead across the rice fields lying in patches through the country, especially if the season of the year be that when the rice is wearing the bright emerald green which distinguishes it shortly after being transplanted. On reaching the furnaces the ore is carefully washed and stored in little heaps as convenient.

With reference to the fuel, the iron smelters of Malabar are very particular in confining themselves entirely to that made from the irool tree, a species of coarse hard timber, which yields a remarkably bright clear coal—the best of which will not stain the fingers when touched, and gives out when struck almost a metallic sound. During none of my examinations of different charcoals have I ever seen a superior coal to this, although the mode of preparing it is quite at variance with our European methods, and wasteful in the extreme. The practice of the burners is somewhat as follows:—

They cut down the irool trees, which have extremely straight clean boles, at a height of about four feet from the ground—this is to save their stooping,—with axes which, like many other Eastern instruments, are exactly the inverse of any we use; for instead of the helve passing through the eye of the axe, the latter has no eye, but is drawn out at the end opposite the cutting edge to a point, which is thrust through a speil in the helve, and secured in its place by a ring passing over the end of this, which ring being forced down draws the two sides sufficiently close together to hold the tool tightly and well. The timber once down is split and cut into pieces varying from eight to ten inches in length by three or four inches diameter, and then placed in a circular hole in the ground in a quantity sufficient to yield, at the rate of six to one, about 56 or 60 lbs. per hole; it is slightly covered over with leaves and earth, and toward sundown, when the men are leaving the jungles, fire is applied. The result of these operations is that in the morning the wood set the night before is found sufficiently charred, and the first part of the day's work is to remove from the holes, and store it in light baskets, which are carried home in the evening on the fellers' heads; each man thus cutting his own timber, setting it in the little pits, and eventually bearing it to the furnaces, where it is paid for by measure. The average price is about four annas or sixpence per basket, equalling at the furnace say £1 per ton; but it must be remembered that this is all as it were hand picked, dry, and in every way of excellent quality. It may be well just here to remark that all this jungle work, and indeed most of the smelting, has to be suspended during the four months of monsoon, which commence about the 15th May, and flood the whole of the flat alluvial plains of Malabar; in fact, the humidity of the atmosphere becomes so great that even were a store of charcoal provided, I doubt whether, from its great moisture-absorbing qualities, it would be possible to keep the furnaces going; in addition to which the natives can scarcely be got out of their houses during this period, which is to them somewhat similar to what the hibernating months are to the Laplander.

The next and last material to be considered is the flux, and for this is used a small shell carried up from the coast; a considerable distance certainly, but then the quantity required is very very small, and a single coolie load goes a long way; the only objection which I can see to the use of such a flux is that in all probability it contains some phosphorus.

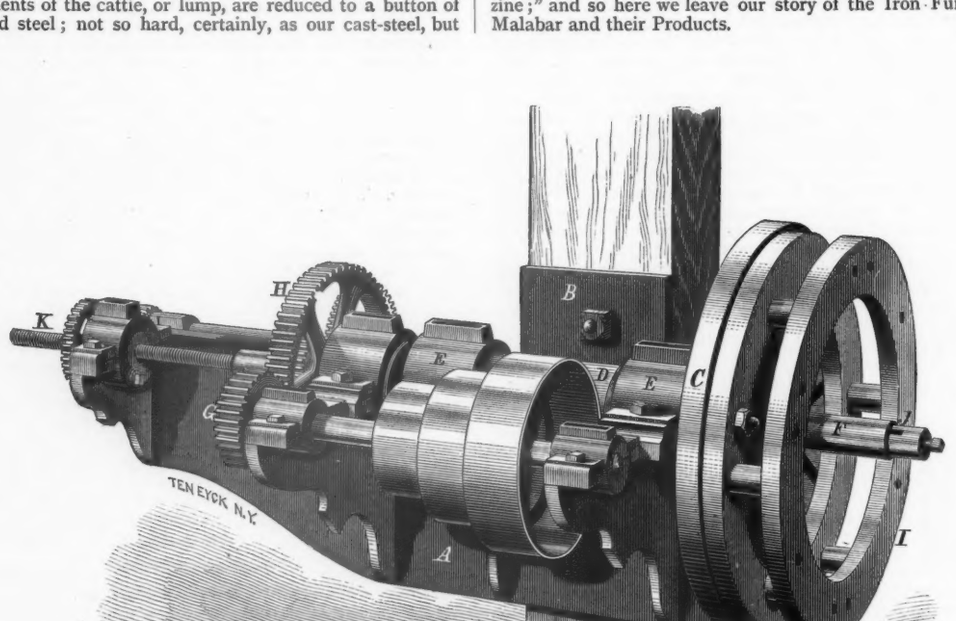
We now come to the construction of the furnace itself; this is built of brick, and lined, or rather plastered, internally with a kind of cement, formed of clay and pounded laterite; it is from eight to ten feet high—section circular—and say fifteen inches diameter at the bottom to two feet at the top, built on a regular batter, without any bellying or sloping boshes as in the European high furnaces. The tuyere holes are placed about four inches from the bottom of the hearth, and the blast is supplied by a couple of men sitting down, and each working a couple of goat-skin bellows, one in each hand; these are about as primitive things as may be, being merely the skin sewn up, leaving an orifice at the neck; and to the other end, which is left open, are attached two pieces of thin wood; these the operator grips one in either hand, and as he raises his hands from the ground the skin is by that means held open; when the full length is reached, they are closed together, and the return movement of the arm forces the then enclosed air into the furnace; the pressure of blast must hence be very low indeed, in fact it would be difficult to form any estimate of it, but it certainly does not exceed one-fourth of an inch of mercury. The furnace itself is first of all filled with charcoal alone, and as this begins to burn down the charge is added in the proportion of about 25 lbs. of ore to 50 lbs. of charcoal; it is not however put on in these quantities, but in little charges of three or four pounds of ore to seven or eight of coal and a few shells; the materials thus become thoroughly mixed, and to this may, I think, in some degree be attributed the quality of the resulting produce. When a sufficiency of material, which experience of the capacity of the furnace readily indicates, has been filled in to form a catty or lump of iron as large as the space between the bottom of the hearth and the tuyeres, the charging is stopped, but the blast is continued until the contents are fairly blown down; time is then allowed, only a few hours, for the iron in the bottom to cool a little, and then the front of the furnace is

broken open, the lump dragged out and cut up into whatever sized pieces may be desired. It should be named here that the yield from the ore is about 20 per cent. in Malabar.

We now come to the question of what species of iron or steel this metal is. It is in fact of two distinct qualities, some portions of it being of a bright steely fracture, whilst others are fibrous, like wrought iron; the better pieces are put aside for the further process to be presently described, and the fibrous or iron-like ones are sold just in this rough state to the smiths, who from them manufacture all the implements used in the country—cart axles and tyres, hammers, &c., by the simplest and most laborious process of ordinary hand-forging.

From the better or, rather, more crystalline parts the well known wootz-steel is made, by melting them in little crucibles with about 10 per cent. of dried wood, cassia auriculata, and two or three leaves of asclepias gigantea,—what the effect of this latter can be seems difficult to say; nor have I found even amongst the writings of the late Josiah Marshall Heath, than whom no one was ever better acquainted with the practice and theory of Indian iron making, anything further than a mention of the fact of its use. The little crucibles are then set in an open circular charcoal fire urged by a gentle blast, and in due course the fragments of the cattie, or lump, are reduced to a button of clean solid steel; not so hard, certainly, as our cast-steel, but capable of being forged into instruments of admirable temper, and taking a cutting edge like that of a razor.

There was something said at the last meeting in England of the Iron and Steel Institute with reference to the yield of wood in this Indian process on which I would desire to say a few words. In speaking of his rotatory furnace, Dr. Siemens referred to the immense consumption of fuel by the Indian process, and said—quoting from some tables prepared by Mr. Lewis D. B. Gordon, F. R. S. E.—that assuming the yield of charcoal from wood at 30 per cent., the actual consumption of fuel in the two methods was as 21·9 Indian to 2·9 Siemens. Now we have seen specimens of the results of both plans, and I wish distinctly to state that to compare anything that ever came out of a Siemens furnace to Indian steel is to compare the texture of a gunny bag to a Cashmere shawl. There can be but very little question that to make Indian iron or steel by the native process necessitates an extensive consumption both of ore and fuel; but that the result is a metal of high value is equally true, and it has long been my opinion that to purchase the Malabar-iron and hammer it on the spot, with a light tilt hammer, into blooms, to be afterwards forwarded for drawing and finishing in England, would be found highly remunerative. But this is not a question for the "Practical Magazine;" and so here we leave our story of the Iron Furnaces of Malabar and their Products.



IMPROVED BORING MACHINE.

NEW BORING MACHINE.[1]

THE invention herewith illustrated from "The Scientific American" is adapted to the boring and turning of pulleys, gears, spiders, &c. A is the bed or frame, which is cast in a single piece, and arranged to fasten to a post, as at B. C is the face-plate which is cast with the hollow shaft, D. The latter fits in the boxes, E, and serves throughout its whole length as a bearing for the bar, F. The cone pulley receives motion from a suitable belt, and transmits it to the gear wheels, G and H. In the hub of the latter is a feather which, acting on a slot in the bar, F, communicates power to the latter.

The work to be bored is fastened upon the chuck, I, as in an ordinary lathe. If the exterior of the object is to be turned, a set screw in the shaft, D, is screwed down upon the bar, F, and motion is thus imparted to the shaft, D, face-plate and chuck. The operation completed, the screw is loosened, the face-plate set by a dog or pawl, and the cutter is adjusted in the hole, J, at the extremity of the bar, F, where it is held by the set screw shown. The shaft, D, now remains motionless, but the cutter rotates with the bar, F. The feed gear is set in motion by a reversible lever at the end of the machine (not shown). K, the feed screw, is held in position by a slot planed along its entire length and a stationary feather or lug to keep it from turning.

It is claimed that this device occupies but little room and will do twice the work of a lathe for the same purpose. It will bore any sized wheel, from ten inches upwards to any required size.

[1] From the "Scientific American."

THE HISTORY OF TECHNOLOGY.[1]

(FIRST NOTICE.)

TO those unacquainted with the deep sentiment which has prevailed for so many years for the existence of an united Germany, Bavaria, although in other ways respected as a home of the arts and sciences, has been looked upon as a land standing aloof in many respects from that sentiment of a common language and a common Fatherland. The political events which conspired to hurl the armaments of Germany against a then mendacious but now repentant France, found Bavaria among the States readiest to support the long-hoped for idea, now to some extent realized. She worthily, and at the cost of the life-blood of some of her very foremost men, vindicated her honour on the field, and then placidly retired to the more congenial arena of science and art to continue her labours on behalf of the more solid interests of humanity. This is a spectacle worthy of our admiration, an emotion which cannot fail to obtain our esteem. It had been in contemplation for a long time to issue from the press at Munich a series of volumes illustrative of the progress made by mankind in the various arts and sciences—to assume an encyclopædic form—but to be so printed that each branch of industry might possess in itself a complete history of its *fact* or faculty, at a price commensurate with very slightly filled pockets.

In order to explain the design of this great historical work, it will interest the reader to be made acquainted with the names of the authors of various sections of it, together with the sections there severally represented. To the readers of the present publication, the practical sciences will naturally have the most interest; and we shall therefore give precedence to those works of a practical nature, either completed or in progress, on subjects connected with them.

Each work being substantially complete in itself, it forms a useful handbook to the subject under consideration, and the authors' names are sufficient to guarantee accuracy in detail. Thus we have for mathematics, Professor Gerhard, of Eisleben; Professor von Jolly, for physics (the German equivalent for what we persistently term natural philosophy); Professor Kopp, of Heidelberg, already known as the historian of chemistry for that subject; Professor Wolf, of Zürich, for astronomy; Dr. Ewald, of the Royal Academy of Berlin, for geology; Professor von Kobell, of Munich, for mineralogy; Professor Sachs, of Würzburg, for botany; Professor Fraas, for agricultural chemistry and forestry; Professor Victor Carus, for zoology; and Professor Hirsch, of Berlin, for medicine and physiology. Passing over the abstract sciences, comprising Roman Catholic theology, Protestant theology, philosophy, æsthetics, classical philology, Teutonic philology and archæology, comparative philology and Oriental philology, the sciences of war, history, jurisprudence, international law, and national economy, all of which subjects find their fitting exponents, we arrive at the interesting topic of technology, to be generally reviewed in the following columns.

For the performance of so onerous a task as the history of technology, it would have been difficult to find any one better fitted than Professor Karmarsch. This author is already well known for several important contributions to scientific literature; and this large volume of more than nine hundred pages goes far to consolidate the literary reputation he has already gained. Every one acquainted with the enormous literature of the industrial arts will admit that it was no slight material to collect together, as we here find it done, the various contributions to the historical aspects of technology. The mere material itself forms an enormous mass of writing, and the completeness with which it has been done is a triumph in itself. A most admirable system prevails throughout this work; before proceeding to notice its special sections, it will be found interesting to glance over the table of contents, so as to get a general view of the matters presented to us.

The first part of the book is divided into three sections, the first of which is occupied with a recapitulation of the condition of the industrial arts at the middle of the last century, the state of mechanics, physics, and chemistry, together with a sketch of the schools of that time and its literature, the condition of the organization of labour, means of transit, and other important points. The second section enters into more immediate details upon the same subjects, in Germany first, and then in other countries. The constitutional condition of labour is considered under its heads of guilds, concessions, and trade regulations; to which succeed sections upon means of intercommunication, as railways, canals, steamboat traffic, posts, and telegraphs. Under another head we find ranged the subjects of patents, trade societies, and private companies. Next, the question of public trade competition engages our attention, including periodical industrial exhibitions, treaties of customs and commerce, and the important topics of unification of coinage, measure, and weight. The third portion of the work enters upon practical details concerning water-engines, such as water-wheels, wind-mills, steam-engines, and caloric and gas engines; under the head of metallurgics we find iron, steel, copper, lead, zinc, tin, nickel, aluminium, alloys, and the working of silver, gold, and platinum. We next proceed to casting, forging, sheet wire and pipe works, together with the necessary tools and machinery; iron and steel goods, metal-button works, coins, gold and silver factories, and watch and clock factories.

The working of natural and artificial stone next receives attention, followed in turn by a general history of pottery and porcelain manufactories. The important subject of glass in its various forms is next passed in review, succeeded by sections devoted to wood and its industries. Next follows caoutchouc and gutta-percha, peltry, and textile fabrics. Finally we have sections on paper and its manufacture; the graphic art, including printing, wood-cutting, copper and steel engraving, and lithography, with the materials for writing and drawing. Manufacturing chemistry is next discussed under the heads of chemical products in their speciality, colours, dyeing, and dyeing materials, terminating with domestic appliances, matches, lighting, and heating.

The second part contains a history of technological science—its object and methods—and a general *résumé* of English and French literature upon the entire subject. To this an admirable duplex index of things and names is added, and some idea may thus be formed of the generally extensive scope of Professor Karmarsch's literary undertaking.

"In all sciences," says the Professor, "not concerned with matters of a mental kind, but busied with outward substances manipulated by nature or the ingenuity of man—that is to say, on all the sciences of experiment—the historical presentation of their development and progress has to do with two things, viz.: with the successive appearance or discovery of objects and facts having relation to matter itself, and then with the progress effected by an intellectual recognition, arrangement, comparison, and systematic description of the matter itself, or in other words, of the doctrine based upon a scientific perception of the uses and properties of the said matter. The natural sciences are in this position. Animals, plants, and minerals in multitude were long known before natural philosophy existed as a science; innumerable physical and chemical phenomena were observed, ere the names of physics and chemistry had any intelligible meaning; scientific astronomy is of a far later date than the simple observation of the stars themselves. Every object of the world of sensation has become known to the consciousness of men, without there existing of necessity a natural science connected with such, however much the latter may have been affected by the presence and observation of the circumstances themselves. The substantive matter of science developes itself or increases originally of itself in an independent manner, becoming in course of time a group of experiences known to the senses; the spirit then arises to examine and arrange this store of knowledge and ascertain its inherent subjection to laws, and thus a science arises which takes for granted the existence of a considerable quantity of knowledge, although it may not be in a state of perfection. In proportion to an increase in the knowledge of facts, the scientific aspect grows in extent and accuracy. Acquiring strength, it soon ceases to act within the sphere of its original series of facts, but acts upon other correlated laws and phenomena, giving rise to increased investigation and to new discoveries. Thus the systematology of zoology allows us to suspect the existence of yet undiscovered classes of animals; computative astronomy fixes the exact position of unknown cosmical bodies in a manner almost resembling prophecy; and chemistry leads to combinations of innumerable bodies never hitherto united by the creative powers of nature in a voluntary manner."

Thus the brute matter of nature, so to speak, is always in an intimate connection with the doctrines in relation to it. The mere facts are so susceptible of variation that they lead to an entirely factitious condition of things applicable to the useful arts in their infinite variety, thus forming the substratum of technology itself. But technology differs from the purely natural sciences

[1] *Geschichte der Technologie seit der Mitte des achtzehnten Jahrhunderts*, von Karl Karmarsch. (The History of Technology from the Middle of the Eighteenth Century, by Karl Karmarsch.) Published at the desire and with the aid of His Majesty Maximilian II. King of Bavaria, by the Historical Commission of the Royal Academy of Sciences. Munich, 1872. R. Oldenbourg.

in the much greater difficulties it has to encounter; while nature is only the constant object of the former class of sciences, technology has to devise means for the utilization of the properties of substances in a new and abnormal way for the convenience of man, and the exigencies of the art of society. While the chemist, of himself in great part an observer, can at will reproduce desired phenomena according to known methods, the technologist has to seek, on the other hand, from the general body of science, that which may become adaptable to the purpose he has in view, under difficulties of the most varied nature, in the most distant climes, and under circumstances of the most problematical success. For instance, he may have to seek for one substance in a distant part of the earth, where snow is ever lying on the ground, or in the depths of the stormy ocean, while the other with which it is to be combined is patiently dug out from immense depths, or obtained by prolonged processes requiring the utmost delicacy. The most common object to be found anywhere and everywhere has to be suitably wedded to almost infinitely unattainable chemical substances, never discovered in a natural state. Here it is that the technologist has his difficulties, and in the successful triumph over the obstacles in his way consists his reward and his merit. The technologist makes use of the crude substances of nature, but regards them with far different eyes to those of the zoologist, the botanist, or the mineralogist—these crude substances are but the raw material to be transformed by his processes into far other bodies, and fitted for uses of which the pure scientific man has and can have no cognizance. The mathematical mechanician is contented with a scientific knowledge of the action of certain levers, pulleys, and the like; but the technologist has to analyze these to see in what way the force they exercise is adapted for the purpose he desires to effect. The very material of which machines are made, its quality and nature, is of importance to the technologist. "Machines to him," as Dr. Karmarsch says, "are not alone beautiful and admirable combinations of levers and wheels, respecting which subtle calculations, very often erroneous in themselves, may be formed; he asks rather in what the principles of construction exist, and what its qualitative and quantitative yield may be, not to be ascertained without a careful consideration for the substance to be produced by the machine, and the technical necessities of the case. Technology ever stands beside practice as a guide and dictator; whatever is produced by pure science—whether it be in mathematics, mechanics, physics, or chemistry—technology endeavours to utilize for the advantage of mankind; technology receives the crude material with thanks but with scrutiny, preserving that which is of value, and casting aside the useless, however mentally attractive in itself, or however deeply thought out by the discoverer. And yet there are many who deny to so important and well proved a judge with such an enormous field of action, the title of a science in itself! Can it be so much longer?"

The history of this science the author proposes to write in a twofold manner—first, in the historical sense itself, as to the progress of the industrial arts themselves—in the history of inventions of important branches of industry, and finally of important state and private industrial undertakings; and on the other hand to show how, from a concretion of purely descriptive labours, there finally emerged a scientific acceptation, investigation, and representation of the subject, or, in one word, technology itself;—how this science gradually grew in strength and assumed a characteristic form; how and by what agencies this event took place and its field of action was gained, and how and in what measure this science has succeeded in taking a befitting place among the ordinary branches of study of our time—aiding and exciting to emulation the various trades to a wholesome competition.

The point of departure, the middle of the last century, has been deliberately adopted, in consequence of the decided impetus which the industrial arts have obtained since that period, comprising within itself an important revolution in chemistry, both in theory and practice; the rise of the steam-engine, the invention of the spinning-machine, and the commencement of a swifter development of the factory trade, and the inauguration of a new and more comprehensive era in technological literature.

It is impossible to look at the condition of the industrial arts some hundred years since without a perception of the enormous strides that have been taken in all directions by means of the new applications visible on every side. It is first perceptible in the conditions of the sciences, naturally forming the groundwork of the whole structure, as at present understood, of the arts; next, it cannot be doubted that an improved method of teaching the sciences has quite altered the aspect of matters in the most beneficial degree; further, a special literature of a most comprehensive kind has arisen not thought of in days anterior, while manufacture has received organization and specific characteristics. Nor is the very important fact of an increased facility of intercommunication to be disregarded; while political enactments, State encouragement, and similar causes have greatly promoted the well-being of the industrial arts. Finally, it must not be omitted that these various causes have led to the establishment and recognition of a separate class of intellectual labourers, whose function is the definite examination of technical matters from a purely technical standpoint.

Turning from the generalities of the science of technology to the consideration of its special branches, we first come to the subject of simple mechanics in reference to the statics and dynamics of solid bodies. In this great progress was effected from the time of Galileo to that of Euler and D'Alembert, who both died in 1783. These two distinguished men were succeeded by Joseph Louis Lagrange, who appeared as a reformer in the field of mechanics. Born in Turin 1736, and professor of mathematics in the School of Artillery of that, his native city, in 1755, but afterwards director of the mathematical class at the Academy of Sciences at Berlin till 1787, whence he passed to the Ecole Polytechnique at Paris, dying a member of the Institute, and of the Bureau of Longitude, a senator and a count, in 1813. The important subject of friction, concerning which very imperfect ideas prevailed, received illustration at the hands of a German, Segner (1758), and afterwards of a Frenchman, Charles Augustin Coulomb (born 1738, died 1806), a member of the Institute. His most important experiments were published between 1779 and 1790, and have received important confirmation from other French and English authorities. The question of the density of bodies was in a very incomplete state until the publication of the inquiries of Musschenbroeck (born 1692 at Leyden, and died at the same place 1761) in 1756. Later writers upon elasticity are Johann Albert Eytelwein (born 1764, died at Berlin 1848), Thomas Tredgold C.E., (born 1788 at Brandon, near Durham, died 1829), Rondelet (1814), Thomas Telford and Peter Barlow (1817), George Rennie (1819), Gerstner and Duleau (1820), Eaton Hodgkinson (1836), Wilhelm Wertheim (1842), Jean Pierre Eugene Napoleon Chevandier (1846), Ardant, Adolph Ferd. Wenzeslaus Brix (1847—1853), Fairbairn (1849-1854).

The mechanics of fluids at the middle of the eighteenth century was in such a backward condition that it was impossible to suspect how greatly the subject would receive development in the period which has since elapsed. Hydrostatics, founded by Archimedes, remained in a very low state until the beginning of the seventeenth century, when some progress was made by Stevin (about 1580), Galileo, Huyghens, Newton, Bouguer, and A. C. Clairault (1743); but it was reserved for Lagrange (1788) to perfect the theory of hydrostatics as at present understood. The motion of fluids in pipes was treated of by Daniel Bernoulli in 1738, who was succeeded by Maclaurin, John Bernoulli, Clairault, D'Alembert, and Euler; but the most decisive experiments were made by Poleni (1717), who remained without any followers for half a century. The hydraulic press, which was the practical result of the theories of Galileo and Stevin, was first produced by Joseph Bramah in 1795; and the mathematical theory of hydrostatics and hydrodynamics was worked up by the Marquis de Laplace (died 1827), Simon Denis Poisson (born 1781, died 1840), Gauss, and others.

Among practical investigators into the theory of fluids it must not be forgotten to name the three Michelottis—Francis (died 1777), Joseph (died 1819), and Ignatius (died 1846); Venturi and Bidone, Borda (1766), Bossut (1778-1782), Du Buat (1779), D'Aubuisson (1830), Poncelet and Lebros (1828), Castel (1835), and Boileau (1847); the German writers on the subject being Langsdorf (1783), Gerstner (1796), Eytelwein (1814-1819), Julius Weisbach (1842-1856, died 1871), and Nicolas Braschmann. Special progress has been made in the mechanics of aeriform fluids within the last half century, to an extent not to have been anticipated a century ago. In a similar manner constructive mechanics has received a gigantic impulse both in method and in the matter of tools.

If we turn to physics proper, we find the theory of caloric in a very advanced condition. The expansion of solid bodies was first investigated at some length by Lavoisier and Laplace about 1780, and next by Dulong and Petit (1816); fluid expansion was illustrated by Dalton, Kopp, and Pierre, and that of water in particular by Hallström (1823), Stampfer (1829), and Muncke (1831), while aeriform fluids were studied by Gay Lussac (1802), whose results have been somewhat corrected by the Swede Rudberg (1837), the German Magnus (1842), and Henri Victor Regnault, the director of the porcelain manufactory at Sèvres (1847). Thermometers and calorimeters have been made in metal and other substances by Breguet of Paris (1817) and Holzmann of Vienna (1819), and many others.

In optics great progress is due to Bouguer, Lambert, Rumford, Ritchie, Potter, Wild, Malus, Dollond, Guinand and

Fraunhofer, Daguet, Barlow, Rogers, Littrow, Plössl, Pistor, Schiek, Kellner, Oberhaüser, Hartnack, Amici, Lieberkühn, Brewster, Allard, Giroux, Prokesch, Rupprecht, Debus, Emsmann, Wollaston, Lüdicke, and Sömmerring.

Electricity has been brilliantly followed up since the days of Franklin by Galvani, Volta, Oersted, Arago, Sturgeon, Faraday, Gauss and Weber, Steinheil, Wheatstone, Stöhrer, Bonelli, Dal Negro, Jacobi, Wagner, Hare (of Philadelphia), Delarive, Kobell, and Ommeganck, of Brussels, 1856.

Analytical chemistry owes its existence to the Englishmen Black, Cavendish, and Kirwan, the Swede Bergman, and the German Wenzel; and in the same field we find Richter, Proust, Dalton, Gay Lussac, and Berzelius, with Berthollet and Humphrey Davy; but the real creator of modern chemistry must be regarded to be Lavoisier, who perished by the guillotine in 1794. An illustrious roll of names might be cited in reference to chemistry, but it will be enough to mention here those of Klaproth, Mitscherlich, Rose, Wöhler, Liebig, Sir Humphrey Davy and Faraday, Berthollet, Vauquelin, Thénard, Gay Lussac, Dumas, and Berzelius. By the investigations of these great students we are separated by an interval of thousands of years from the bald knowledge possessed by the world in 1750—the whole nomenclature of chemistry has been changed; the names of the very elements would be unintelligible to the chemists of that time, and the whole method of analysis is of an entirely different character.

Probably there is not a single existing trade or branch of manufacture which has not materially advanced since the middle of the eighteenth century; many have been totally metamorphosed by the inventions which have been introduced and the improvements made in the several processes, while some arts have wholly disappeared, and others presented with entirely new features, some of them having assumed proportions of the most gigantic importance. Commercial production has quantitatively increased in an enormous ratio, and has led to quite novel interrelations between the various branches of trade and consumption, and factories on a colossal scale have taken the place of small centres of individual activity. The picture presented by the industrial arts is therefore not only wholly new, but far more grand and impressive; and this is equally true in whatever direction we may turn. To take a single instance of a new trade, we may refer to india-rubber, which first became known in Europe about 1740. Into what an infinitude of technical trades does not this substance enter! The chemist, the electrician, the railway engineer, the upholsterer, the clothier, and a number of other commercial industries, all require this substance, manipulated each according to the special requirements of the business; and in a similar manner gutta-percha, a substance known to us comparatively yesterday, employs thousands of busy hands in its preparation as an industrial product. Again, the modern methods of preparing leather were wholly unknown to our predecessors of a hundred years since.

But a very special progress has been made in all matters connected with weaving and spinning, and the preparation of animal and vegetable textile substances of this kind. Jute, Manilla hemp, New Zealand flax, aloe hemp, China grass, cocoa matting, and the like substances, are all of modern introduction, and the new materials have required and produced new kinds of machinery adapted for their manipulation. Paper manufacture, in like manner, has been wholly transformed, both as to processes and materials employed: and here again the machinery has far outrun all that was known about 1750. The application of a mixture of cotton and paper for collars, shirt fronts, wristbands, and other wearing apparel, is of yesterday, speaking as it were by comparison. The envelope trade, too, is quite of recent origin. If we turn to the graphic arts, we again are struck by the numerous improvements effected in their various branches—we have not only lithography, but autography, zincography, steel-engraving, hyalography, nature-printing, galvanography and galvanoglyphy, glyphography, and half a score of other methods. Xylography, again, has become an art practised to great perfection, and the typographic art is now supplemented by stereotyping and kindred modes of cheap reproduction. The nickelization of type in printing is now being adopted in all large establishments; and finally, it is hardly necessary to do more than name daguerreotyping, photography, photoglyphy, heliographic steel engraving, photo-lithography, photo-zincography, and phototyping.

A great revolution has been effected in matters connected with the preparation of food. The mill of 1750 no longer exists, and all the processes of grinding corn and cleansing the wheat are entirely changed. In baking, improved ovens have taken the place of the primitive oven of a century ago. In sugar-making, beetroot and carrots have been introduced. Chocolate manufacture is entirely reformed and effected by machinery. Brewing and distilling, in a similar way, are conducted according to widely different principles. In fact, we might prolong this list of improvements to an almost indefinite length, and yet not exhaust the subject.

Perhaps the enormous advance which has been made in chemistry is the most astonishing event in the history of technology during the past hundred years, and with this progress is intimately allied that of many special branches of industrial enterprise. New chemical combinations have influenced these various trades to an extraordinary extent, and it is quite impossible to say how far the industrial arts may be modified by the continued activity exhibited in the laboratories of our chemists in England and abroad. The immense stimulus to the dyeing trade given by the introduction of aniline colours is one among many examples of this important and gratifying fact.

Lastly, the entirely new inventions connected with lighting and heat deserve our attention. A century in these particulars, as in so many others, has witnessed astonishing changes, and no doubt other improvements of no less important a nature are destined ere long to be made. In fact, to use the words of Dr. Karmarsch, at the close of his introductory conspectus, we may say that "the impressions awakened by the results of human thought within the short period of one hundred and twenty years are most overpowering, resembling somewhat the feelings of a person surveying a desert wilderness from some elevated point, and then turning rapidly to behold the wide expanse covered with smiling villages, magnificent palaces, and a population of active labouring human beings" (p. 57).

It is beyond the intention of the historian of technology, as our author informs us, to enter upon specific details concerning the history of the sciences allied with it—that is to say, it is not proposed to write the history of mechanics, physics, or chemistry, nor is it necessary to deal at length with the kindred subject of technical literature. The most important point, in the first instance, is to take cognizance of the means and methods by which this enormous revolution in the industrial arts has been brought about. Educational institutions of a varied character have been called into existence in various countries; and according to the genius of the various nations among whom they have been established has been their proportionate success. However much these schools and institutes may owe to the early efforts of such men as Descartes (in France, about 1630), Amos Komensky (1614), Ratech (1630), Semler (1706), Vultejus (1709), Marperger (1723), and Grosser (1739) in Germany—it is certain that their developments and practical utility date from the early part of our own—the nineteenth—century. Of course, for the sake of simplicity, it will be best in considering these various technical institutions, to follow Dr. Karmarsch's arrangement, which naturally begins with those of his native country.

GERMANY.—The first school of any note then established for the promotion of technical knowledge, may be regarded as that of the Abbé Jerusalem, founded in Brunswick in 1745, known as the Carolinum. This was intended to supply a link between the gymnasia of that time and the universities, and to afford special classes for the study of agriculture, trade, the mechanical arts, and commerce; but it was not until the year 1835 that a special branch of this institution was devoted to the appreciation of technology properly so called, since which time, by 1863, it has grown into a complete polytechnic school. Almost at the same time, in 1747, Hecker founded the Realschule in the Trinity Church at Berlin. This is now a royal school in which instruction is carefully imparted in matters of a technological nature. In 1770 a similar institution was established in Vienna, afterwards (1815) united with the Polytechnic Institute, and serving as a preliminary school. Austria was very early in the field in the opening of normal schools, and at the present time abounds with useful institutions of the kind. In Prussia such technical schools began to arise about 1813, when Frankfort-on-the-Oder set the example, speedily followed by Krefeld and Magdeburg (1819), Halberstadt (1822), Barmen (1823), Cologne (1828), Elberfeld (1830), and the Metropolitan Commercial Academy of Berlin, in 1828. Wurtemburg, Nassau, and Hessen soon possessed similar schools.

The most effectual aid that technical education has received in Germany dates from the year 1830; from this time special industrial branches of art were in a greater or less degree made a matter of exact instruction, so that the industrial classes themselves were placed in a position by which greater skill and consequent efficiency were insured. This was done, first, by the establishments of higher (polytechnic) colleges, and, second, by the establishment of trade schools of the middle and lower classes of labour. This movement was accompanied by the unusual phenomenon, that everything was done as it were *de haut en bas;* the higher technical schools were first created, and to them were appended the lower handicraft schools, and even the preparatory schools, whence recruits were to be expected. In consequence of this, the collegiate establishments were forced to

accept in their scholars a much lower standard of attainments, and hence their lecture-rooms were thronged with juniors, not fitted by previous instruction or the bent of their studies for the mode of tuition there adopted.

Of course, this tended to a reorganization of the whole system, which, as it at presents stands, affords a regular curriculum of study. In all parts of Germany, this rearrangement of classification has been found necessary, and time has brought about the fitting modifications. As the system now exists, we find first polytechnic schools (colleges, with certificates whence students may emerge into real life); intermediate schools, having for their object the study of the higher branches of the industrial arts and commercial life; and, finally, preparatory trade schools in which rudiments alone are conveyed to the scholars, at an age when it is yet doubtful to what ends the individual sympathies or capabilities of youth may be applied. Even this last class finds subdivisions necessary, as some special institutions in all parts of Germany have been devoted to architectural and handicraft schools proper. These last educational establishments have arisen from mechanics' schools, held on Sundays, and Sunday drawing schools. Of a different class are the special trade schools (Gewerbliche Spezial-Schulen); these deal only with the technicalities of mechanical art in its various branches; of this last class we may mention the spinning schools, sewing and knitting schools, and schools for instruction in the silkworm trade. Straw-plaiting schools also at one time existed, and even schools for the lace-making trade. Machinery, however, has very materially affected these, and they have in great measure been superseded.

We find a watchmaking school opened at Furtwangen, in the Grand Duchy of Baden, in 1850, and weaving schools are common in many parts of Germany. The oldest of these last was established at Elberfeld in 1845, but it lapsed about 1868. Other similar institutions have, however, arisen at Mühlheim on the Rhine (1852), Krefeld (1855), and Grünberg, in Silesia (1864). Art and design schools also exist in many places. Those who had been in the habit of regarding Germany as a land of dreamers, tobacco-smokers, and abstract philosophers, will find their preconceived notions somewhat rudely shocked at perceiving that country in a state of industrial activity, at least equal to that of our presumed practical England. We are, however, so much engrossed by the contemplation of our own manufacturing supremacy, that it seems utterly chimerical to fabulate about continental countries and their system of education. Yet are we not at the present time still in the throes of labour regarding a national system of education, with costly machinery to boot? and is not a national technical university a thing as yet to be hoped for and agitated about by the wise few, assisted by a select number of paid lecturers and promoters? Continental countries are not accustomed to make such a great cry about so little wool.

What has been said of Germany applies, as may be supposed, to the Austro-German provinces; and a similar state of things prevails in Polish Austria, Hungary, Galicia, Dalmatia, Croatia, and the Bukowina. Switzerland possesses a polytechnic school at Zürich since 1855, and lower schools (trade and mechanic schools) abound. At Geneva there is a drawing and modelling school; and practical watchmaking schools have existed in the same city since 1824, and at Chaux de Fonds, Locle, since 1831.

FRANCE.—On turning to France we find at the apex of their industrial academies the famous Ecole Polytechnique, founded 1795; but it has been sadly warped from its original purpose. It is now, and has been for many decenniaries, nothing but a preparatory engineering school for military and civil engineering—the inmates of which complete their education in special institutes, where they qualify themselves for the artillery, the general staff, for mining, and bridge and road architecture. It can therefore scarcely be regarded as a technical school in the strict sense of the term, only possessing general attributes of that character. Very similar, however, to the German trade schools is the école centrale des arts et manufactures. This, despite imperial patronage, is a private undertaking. For a medium class of technical instruction there are three State schools of arts and crafts (écoles des arts et métiers), the first of which was founded at Compiègne in 1803, the second at Beaupréau in 1811, and in 1843 the third was established at Aix. The school at Compiègne was removed to Châlons-sur-le-Marne in 1806, and that at Beaupréau in 1815 to Angers—receiving different organizations in 1827 and 1832. They differ from the German schools in the particular that besides the professorial lectures, practical handicrafts of various kinds are pursued—but they are all under military regulations, and hence are foreign to English as well as German ideas. Similar establishments exist at Marseilles, Lyons, Lille, and other places. The oldest provincial school of this kind was established at Nevers in 1822, and the most recent at Sainte Marie aux Mines in 1863.

Schools more analogous to the German realschulen are rare in France. Probably the Collège Chaptal and the Collège Turgot, both in Paris, are the nearest in method, and public lectures are given in many cities and towns on sciences allied to the industrial arts. By a decree of 1854 power was given to unite courses of lectures on geometry, drawing, &c., with the various existing faculties of science. Of schools more resembling English mechanics' institutes several have been started by two companies—the Polytechnic Association (1831) and the Philotechnic Association (1848). The first-named body had in 1864 four establishments in Paris itself, three in the neighbourhood, and four more in the departments—the last, at the same time, possessed three schools in Paris, four in the neighbourhood, and one at Nice—the two companies together employing over one hundred and fifty teachers. Instruction is given in the evening, and only during the winter months. The schools established by the Imperial Messageries at La Ciotat near Marseilles, the great machine factory of Graffenstadt in Elsass, and the four Imperial armsfactories for their workmen, deserve special mention. Progressive schools existed in France in 1864 to the number of twenty-six; the first of these was opened at Clermont in 1824, and more than half of the rest date from a more recent time than 1850.

Handicraft schools.—Of these two exist in Lyons for silk-weavers, founded respectively in 1831 and 1862, weaving schools also exist at Nîmes (1856), and Tourcoing (1857), a dyeing-school exists at Nîmes (1820), and public lectures on chemistry for dyers have been given in Lyons from 1860, and in Amiens from 1863. Lacemaking schools are now opened at Dieppe, Bailleul, Bayeux, Saint Brieuc, Creuzol (1843), Mende (1858), and Murat. Watchmaking schools were formed at Macon (1831), Besançon (1862), and in Cluses, Sallanches, and Thones. Schools of technical drawing exist to the number of about forty, nine being situated at Paris; most of these date from about 1820.

We should not omit to mention the important and popular course of lectures delivered for many years free to the working classes, at the Paris Conservatoire, on arts and manufactures. Here an attempt was first made in 1796, to establish a school of technical drawing, with lectures on geometry; but gradually, between 1829 and 1852, other subjects were added, such as mechanics, chemistry, physics, descriptive geometry, national economy, trade legislation, spinning and weaving, dyeing and stuff-printing.

BELGIUM.—The scientific side of technology has not as yet assumed due proportions in that country, regarded from the point of view of instruction. The two State universities of Liège and Ghent have higher technical schools appended to them, and these are connected with the ten gymnasia called Athenæums and Colleges in which industrial sections have been formed. These higher technical schools arose gradually from 1835, but were changed in their regulations as gradually, and finally were settled on their present basis in 1853 to 1856. At the University of Liège there is a preparatory school (école préparatoire), a school of mining (école des mines), a school of arts and sciences, comprehending the manufacturing arts (école des arts et sciences), and a school of mechanical apprentices (école des élèves mécaniciens); at the University of Ghent there exists a preparatory school, a school of civil engineers (école du génie civil), and an école des arts et manufactures. A medium degree of general scientific preparation for industrial purposes is afforded by the école centrale at Brussels, and by the medium schools (écoles moyennes) of Belgium, some fifty in number.

It has been in vain endeavoured to establish trade schools in connection with workshops as in Germany, but the institute for industrial schools has made its footing good, the instruction only taking place in the evening. The most important establishments of this kind are at Liège (since 1825), and at Ghent (since 1826, reorganized in 1835). The technical drawing schools were mostly set on foot in the eighteenth century, but they have been repeatedly assisted in 1817, 1829, and 1852; in number they amounted up to 1840, to nearly forty. Workshops of apprentices and labour schools have been erected severally for the sexes. Of the former, the majority consist of weaving schools of a very normal kind; but we also find glove-making schools, nail-making schools, and schools where domestic furniture and appliances are made. The whole of Belgium in the year 1852 did not contain more than seven hundred and forty industrial schools, and even these are visited by a population of a notoriously roving character; and this a country vaunted for its triumphs of iron working, smelting, and machinery!

THE NETHERLANDS.—The kingdom of Holland until 1842 possessed at Delft an academy for civil engineers, which has, however, been abolished, and a polytechnic school substituted for it. By royal rescript, trade education has been regulated from 1863 in the following manner. The public schools decided upon are:—Citizen or commercial (general) schools, as day-

schools with a curriculum of two years (similar to the curriculum of the German schools) or evening schools (like those of the progressive schools in Germany for mechanics); higher schools with a curriculum of three or five years (having some analogy with the realschulen of Germany) and architectural schools. In every commune of 10,000 or upwards, there shall exist a citizens' school (Bürgerschule) to be held morning and evening; the number of schools subvented by the State was fixed at fifteen—at least five of these to have a course of studies occupying five years. There is only one architectural school. At the Hague there exists a Royal Institution of Engineers.

GREAT BRITAIN.—It must be confessed that what Dr. Karmarsch says of British technological institutions is at the present time unfortunately too true. He observes (p. 87):—"As to the arrangements for technico-scientific instruction in this wealthiest of all the industrial States, they are confined to fragmentary attempts without any general plan, and without any organic interconnection, dependant upon individual necessity and conception for existence and form. The most elementary education was neglected in the last century to that extent, that Sunday-schools themselves were not adopted until after 1785—which Sunday-schools even now, although very numerous, merely confine themselves to religious instruction and reading, while the night schools introduced since 1839 afford very little more. Everything since established of a specially technical character is of a period far more recent; and it is worthy of remark as a phenomenon excluding all practical organization, that what has been done has not emanated from the government, but has been called into life by private endeavours. This principle, so foreign to our German ideas, is still so deeply fixed that the attempt in 1853 to form a Polytechnic Central School in London at the cost of the State, fell through in Parliament. The often highly vaunted Royal Polytechnic Institution in London is nothing more than a collection of models formed by a joint-stock company in 1838, in illustration of which lectures are delivered every evening upon scientific and industrial subjects, having no mutual reference to each other. Similar to this are the lectures (also held in the evening) delivered at the Kensington Museum. Regular and organized instruction of a higher kind in technical science is given at certain institutions on the model of the universities—especially at King's College (established 1828), and at the Royal Colleges of Belfast, Cork, and Galway, in Ireland, since 1849. The Scientific Society of Dublin, the School of Arts in Edinburgh, and the Anderson University in Glasgow, have caused lectures to be delivered by special professors on technical chemistry and mechanics.

"Actual preparatory schools for higher technical education, similar to the German Real and Trade Schools, are entirely wanting in England and the grammar schools, somewhat resembling our gymnasia, afford very little instruction in mathematics, the natural sciences, and drawing. The drawing-schools founded in 1837, however, have done good service, especially as they have been placed upon a better basis since 1857; of these there were in 1851, 21; in 1857, 69; and in 1860, 77. They are divided into two classes: elementary drawing-schools, existing independently in the larger cities, and appended to other schools in smaller places, and schools of ornamental art, of which some thirty existed in England in 1862. Schools of science have since been established where, in a session of one year, instruction is imparted in drawing, mechanics, physics, chemistry, and natural history; of these there were in 1862 seventy-six existing in forty-eight cities, twelve of them being situated in London.

"A great number of Mechanics' Institutes exist throughout the country, resembling the progressive workmen's schools of Germany. The first attempts to establish these were made in Birmingham in 1789, and Glasgow in 1799; but the development of these institutions is to be dated from the time of their re-foundation in Glasgow (1821) and London (1823). In 1853 there were 180 of these institutes, and in 1864 nearly 800. Evening instruction for working men has also been given at the Working Men's College (since 1854), at King's College (since 1856), and in the colleges of large cities, such as Manchester and Liverpool." It is somewhat sad to be obliged to confess that up to the present time nothing of a really substantial or comprehensive character, worthy of English institutions in general, has been called into life; unprejudiced observers of the course of events can as yet descry little that is promising in this most important of all subjects.

DENMARK.—A polytechnic school has existed at Copenhagen since 1829; a technical institute founded by the Technical Society, where practical instruction is given in the different branches of metallurgical science, has been in operation since 1843; and there is also, since 1800, the Massmann Sunday School for mechanics, in which reading, writing, arithmetic, and drawing are taught.

SWEDEN.—In 1826 the Technological Institute was founded at Stockholm, and the Chalmers Mechanical School was formed at Gothenborg in 1829. The Swedish Trades Society supports a trade school at Stockholm, and there are also several Sunday Mechanics' Schools. Practical study is also encouraged in the gymnasia or higher elementary schools, of which there exist about thirty.

RUSSIA.—A technical institute was founded in Moscow in 1825; the Technological Institute was opened at St. Petersburgh in 1831; Helsingfors had a technical school in 1847, remodelled in 1859. Two other institutions exist in Finland of a similar nature of a more elementary kind at Abo and Wasa. In 1861 a polytechnic school was established at Riga, together with a gymnasium; and another school, existing from 1860, was enlarged in 1866 at Mitau.

GREECE.—A university and polytechnic school is in operation at Athens.

A further portion of this very great subject—comprehending the guilds and associative enterprises by which technology has been converted into a positive or political science—will be considered in our next.

K. R. H. M.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(69.)

ORNAMENTAL Cut Wood-work with Working Lines and Centres.—Continuing our designs in this department, we give in fig. 330 one for a single eaves-board, or barge-board. In this the height *a b* is divided into seventeen equal parts. The upper range of mouldings is terminated between the third and fourth points from *a*. Divide the fifth and sixth points into two equal parts, and through the point of division, *e*, draw the line *c d*. From *e* as a centre, with radius *e* 4, describe the circle as shown, and from *e* draw with the right-angled set square the lines *f e f*, *e g'*. Through the eighth point from *a* draw the line *h i* at right angles to *a b*, and from point 8, with distance 8 *e*, set off to the points *h* and *j*, and from these as centres with two of the parts at *a b* as radius describe parts of circles as shown. Through the eleventh point on *a b* draw the line *k l*. With seven and a-half parts of those in *a b*, from the point 11 in *a b*, set off on the line *k l* to the point *o*, and through *o* draw the line *p q*, which will be the centre line of the next part of the design. The distance *o r* equals *o* 11, giving the point or the centre line of third part. Join *q s* being equal to 11 *n*. Through *u t* draw *t u*. From *v* with one and a-half parts of those on *a b* set off to *w*, and from *w* describe the arc as shown, and finish as in the drawing. In fig. 331 we give another design for a single eaves-board, in which the height *a b* is divided into fifteen equal parts, the upper mouldings being set up from *a*, and being equal in depth to two of the parts in *a b*. Through the 2nd, 4th, 5th, 6th, 7th, 9th, and 13th of these parts draw lines at right angles to *a b*. Bisect the space between the 14th and 15th points in the point *c*, and through *c* draw *c d*; from this will be found the centre lines and centres of lower part *a* of design. The distance 13 *e* 13 *f* is equal to three of the parts in *a b* and *f g'* equal to a half part, *f g'* being divided into two equal parts in the point *h*, a line *h i* gives the centre line for the ornamentation as shown, while *h j* is equal to *h* 13 and *j k* gives the centre line of second part of the design. The centres and centre lines are all divisions or multiplication of the parts into which *a b* is divided. In fig. 332 we give the design of a "double eaves-board," in which the height *a b* is divided into eight equal parts, divisions and multiplication of which give the centres and centre lines of all the parts. It will be observed that we have given in the various parts of the design several methods of filling up the ornamentations. The upper range of mouldings, A A A, take up in depth one of the parts into which *a b* is divided. The lower moulding, B B B, starting from the 4th point, and being in depth equal to one half of one of the parts. The width *c d* of one of the parts of the design is equal to two of the parts on *a b*, the distance as *d e* between two subjacent parts being equal to one of six parts into which *b* 1 is divided, *e f* being equal to *d* 1 or *d c*, *f g* being the centre line of the second part of the design. In fig. 333 we give a design for a bracket, of which the height *a b* is divided into five equal parts, *c d* being the projection from wall, and equal to four of the parts

Fig. 330.

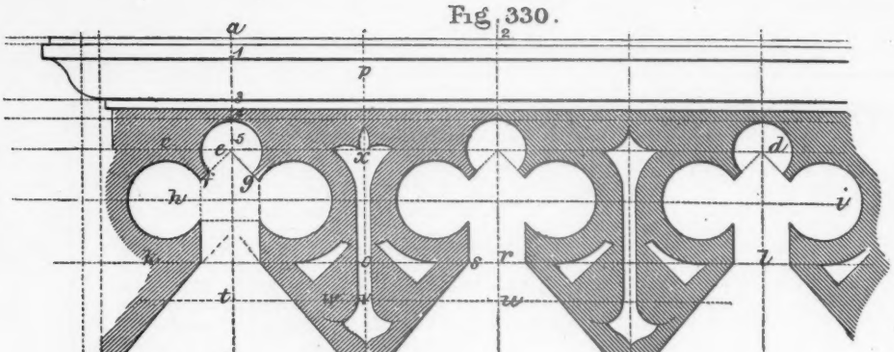


Fig. 338.

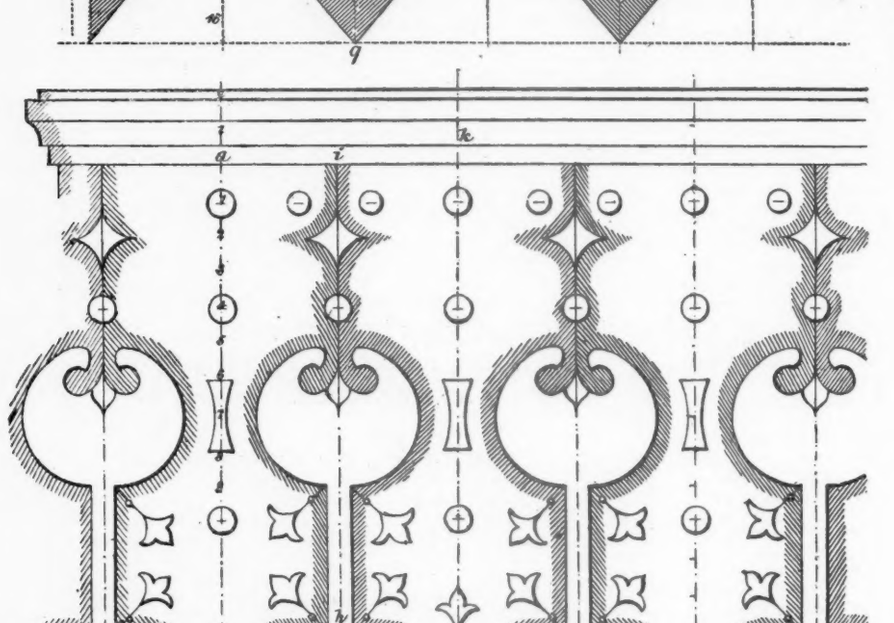


Fig. 339.

Fig. 331.

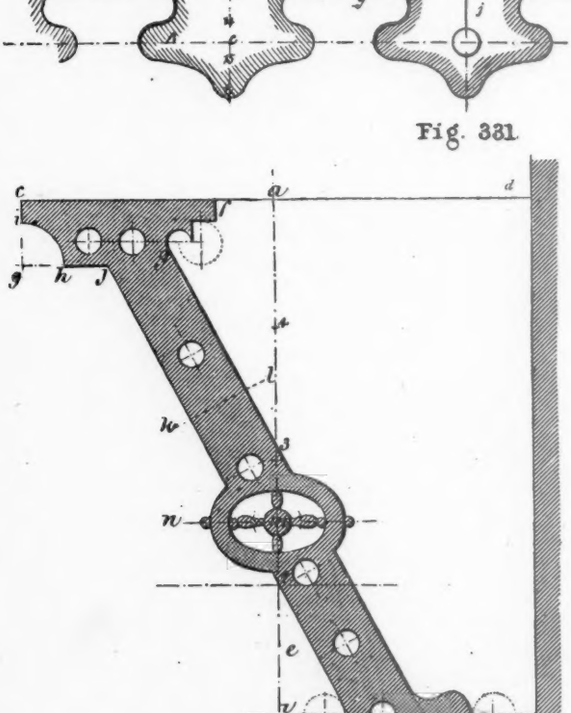


Fig. 333.

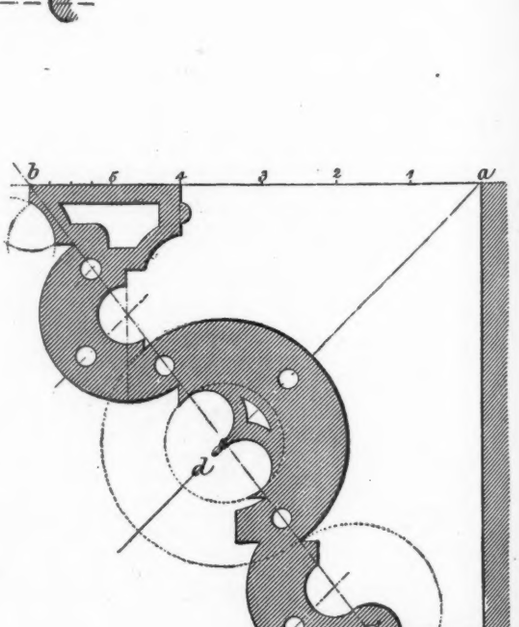
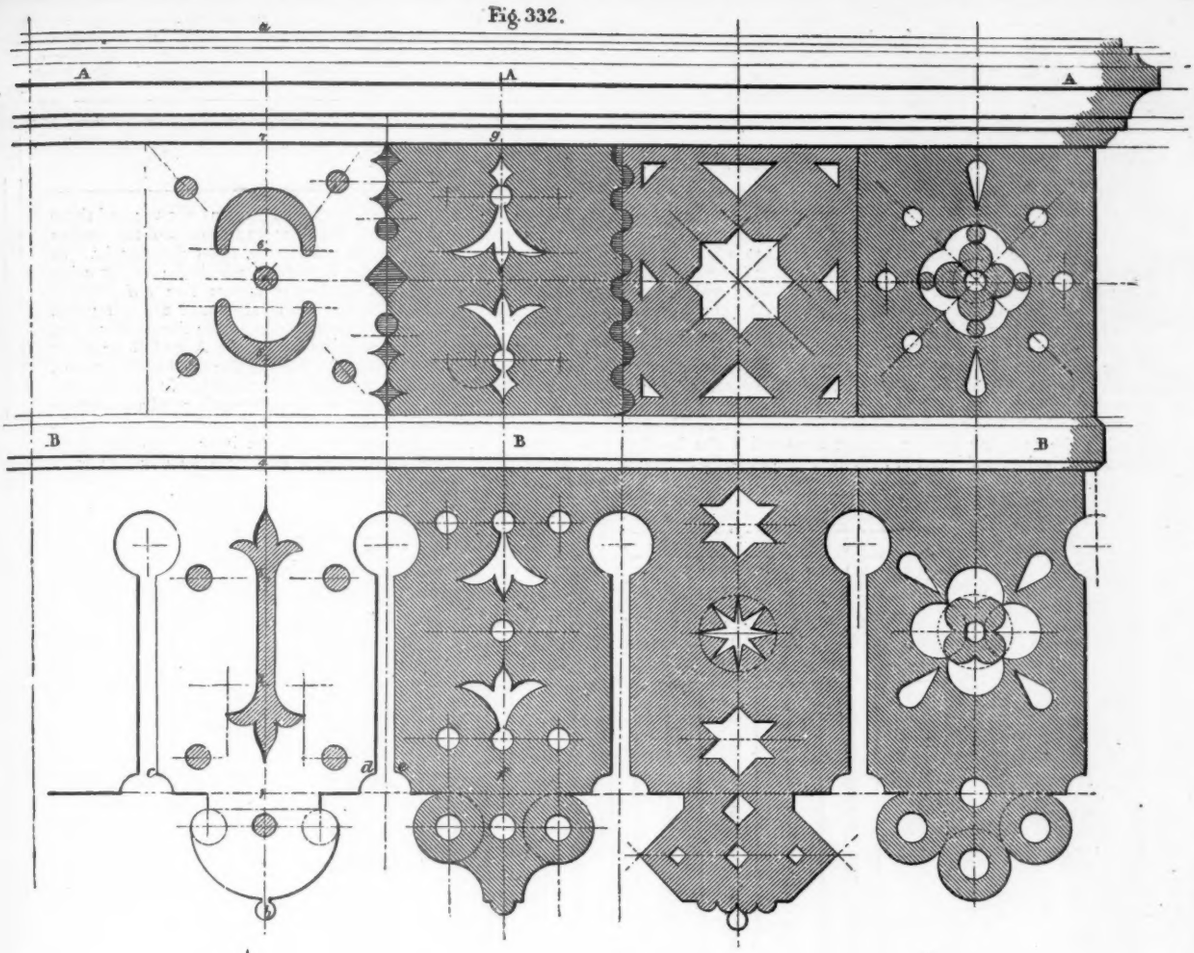


Fig. 334.

Fig. 332.



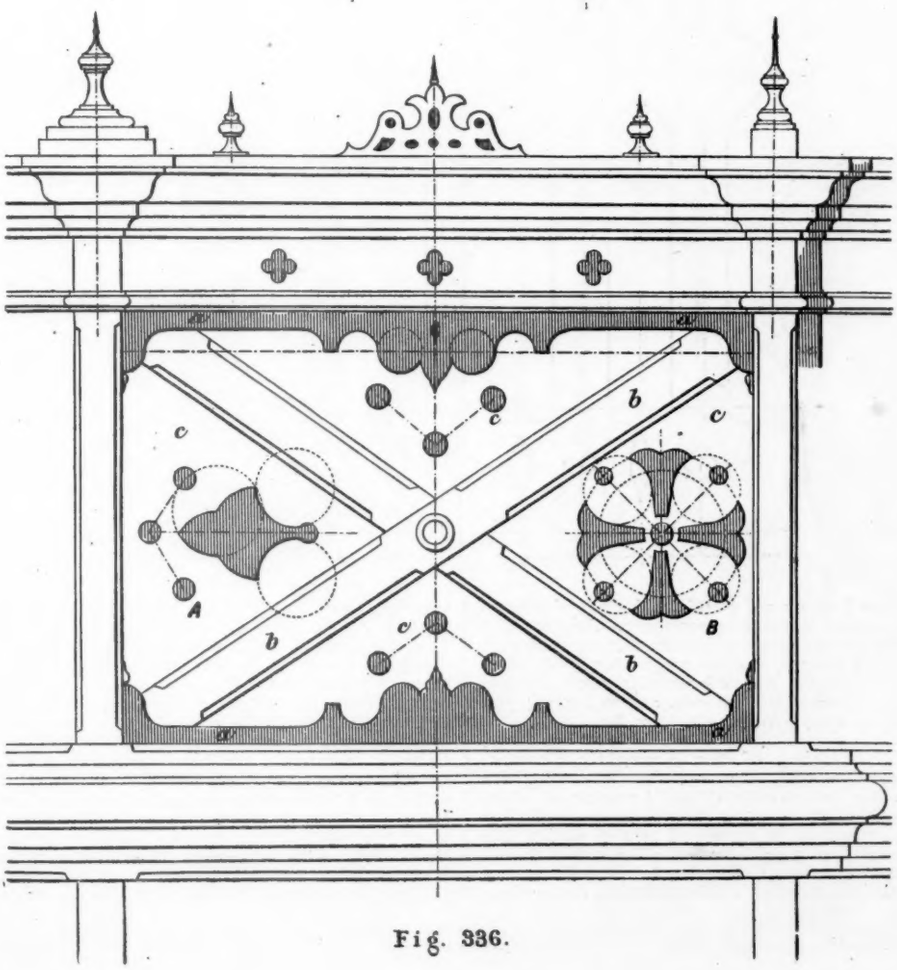
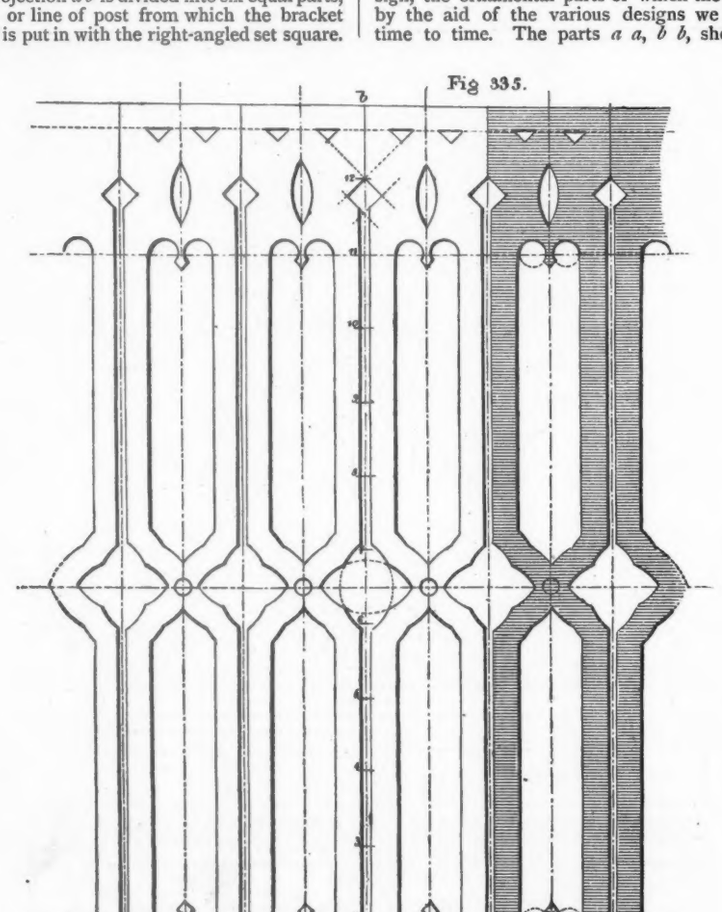


Fig. 336.

in *a b*. Through the point *a* the second of these on *d c*, draw *a b* at right angles to *c d*. Make *c f* equal to one and a-half parts of those in *a b*. From *c* draw *c g* parallel to *a b*, and equal to three of the parts into which *c f* is divided, *c i* and the part *f* is equal in depth to one of the three points into which *c g* is divided. From *g* as a centre with *g i* describe the quadrant *i h*. Make *h j* equal to *h g*. Make the width *k l* equal to *g c*. Bisect the 2nd and 3rd points on *a b* in the point *m*, and draw *n m*, drawing in at this point the elliptical part as shown. From *m* set off in *n m* points equal to half *k l*, and draw the lines *j p g r*, and finish as in the drawing. In fig. 334 we give the drawing of another bracket, of which the projection *a b* is divided into six equal parts, *a c* being the wall line or line of post from which the bracket projects. The line *a d* is put in with the right-angled set square. The part *b* 5 is divided into four equal parts as shown; and these and the other parts give all the lines and centres of the design as shown, the centres being principally upon the line *b c*. In fig. 335 we give a design for a rail—in which the height *a b* is divided in thirteen equal parts—the centre line *c d* passing through the point of bisection of the sixth and seventh parts. In fig. 336, we give a design for a balcony side; the parts *a a a a*, *b b b*, projecting before the parts *c c c*. At A and B we show different methods of cutting into parts of the solid portions, *c c c*. We have already given designs of various kinds of "kiosks" and garden structures; in fig. 337 we give the outlines of another design, the ornamental parts of which the student should put in by the aid of the various designs we have given him from time to time. The parts *a a*, *b b*, should be filled in with

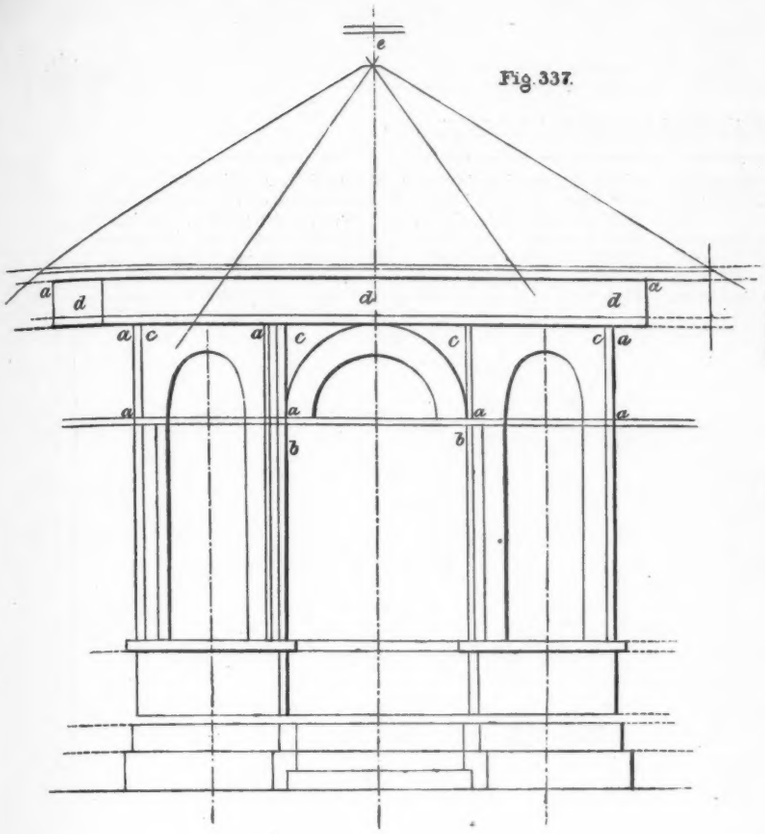
Fig 335.



brackets; the spandrels, *c c*, and part *d d*, with appropriate ornaments, and the lower range with drop ornaments—the part *e* with a finial. Continuing our suggestive sketches upon cut wood-work designs, we give in figs. 338, 339, 340, suggestions for drops or terminals according as the point *a* is upwards or downwards in figs. 341, 342, 343, designs for brackets, and in figs. 344, 345, 346, suggestions for designs from centrepieces, &c.

(70.) **The Describing of the Eccentric Curves, the Ellipse, Cycloid, &c.** — Before illustrating the methods of finding the curve of ellipses by means of points, we shall add one to the methods already given for finding the approximative curves by means of arcs of circles, this being illustrated in fig. 347; let *a b* be the conjugate and *c d* the transverse diameter, intersecting in the point *e*, continue *e a*, *e b* on both sides of *c d* indefinitely. Assume any two points as *f* and *g* as the foci of the ellipse, making *e g'* equal to *e f*, and equi-distant on both sides of the centre *e*. Take the distance *c f*, and set it off from *a* to the point *i* on the line *a e*, and join *f i* by a straight line. From *f* and *i* as centres bisect the line *f i* by arcs cutting in the points *j* and *k* through those points draw a line, *j k l*, cutting *a e* produced in *l*. From *l* through the point *f* draw a line *l f h*. From *a f* with *f c* describe an arc *c h*, cutting the line *h f l* in *h*, and from *l* with *l h* describe the arc, *h m* from *g*, with *g d* describe the arc *d* in cutting *l g m* in *m*; half of the ellipse will thus be produced. We now come to explain the methods of obtaining the curves of ellipsis by means of a series of points. In fig. 348 let *a b c* be major or transverse, *a d* the minor or conjugate axis or diameter. From *a* as a centre, with *a d* as radius, describe the semi-circle *f d e*; and from the same point, *a*, with radius *a b*, describe the semi-circle *b g c*. Divide the circumference of

Fig. 337.



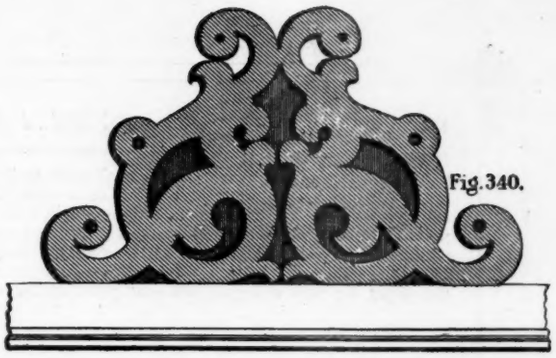


Fig. 340.

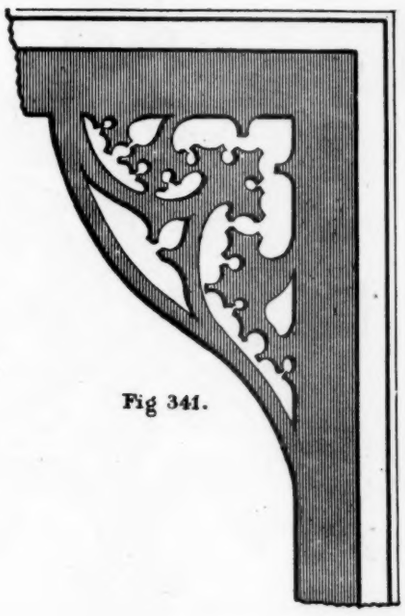


Fig 341.

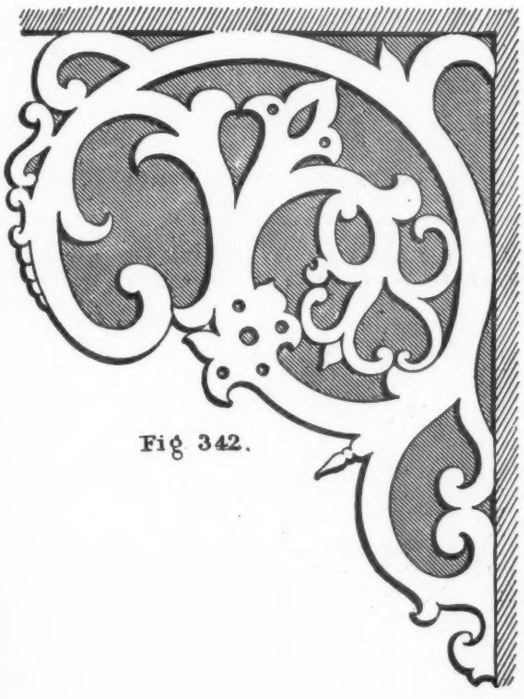


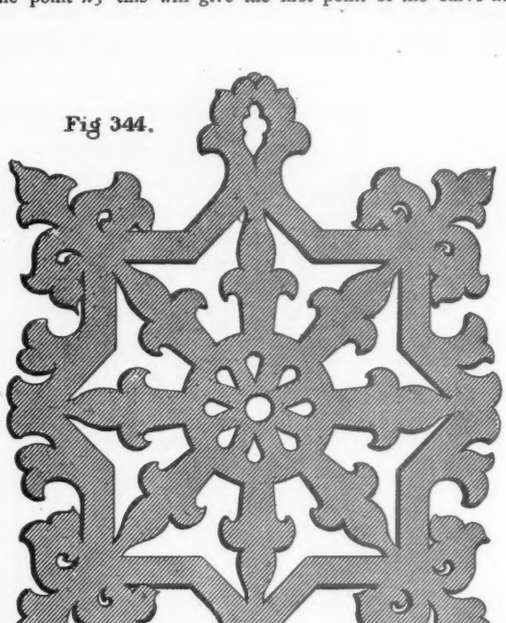
Fig 342.

Fig. 343.

Fig. 346.

the largest circle into any number of equal parts, as in the points *h i j k l* and *m*, and through these points draw radial lines to the centre *a*, cutting the circumference of the smaller circle *f d e*, in point as in *o q v w x* and *y*. Then, from the point *o*, on the quadrant *f d*, draw a line parallel to the diameter *b c*; and from the point *h*, on the quadrant *b g*, draw a line at right-angles to this from the point *h*; this will give the first point of the curve at *n*, where the two lines intersect. From *q* draw a horizontal line *p q*, and from *i* a vertical line; the intersection of the two lines will give the sectional point of the curve on the point *p*. Proceed thus by drawing a series of horizontal lines from the points *q v w x y* in the quadrant *f d*, and a series of vertical ones from the points *j k l* and *m* on the quadrant *b g*, the intersection of these lines with each other will give a series of points, *r s t* and *u*,

Fig 344.



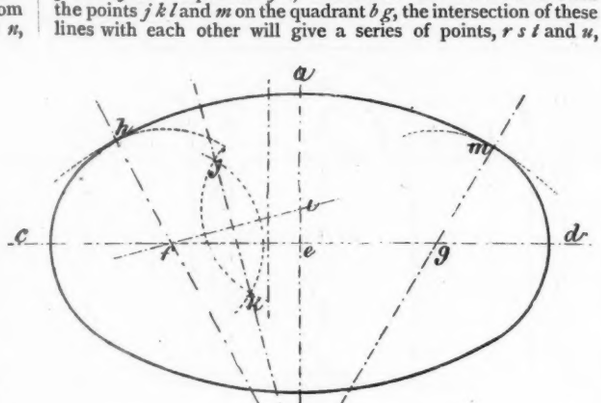
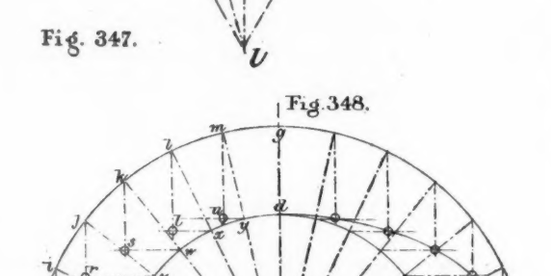


Fig. 347.

Fig. 348.



through which the curve may be drawn by hand, thus completing one-fourth of the curve; the other three-fourths are obtained by a repetition of the process. The points of intersection are shown in the diagrams by small circles, and the curve to the right hand is put in as shown in passing through the points. In fig. 349 we illustrate another method of finding the curve of an ellipse by means of a series of points. Let *a b* be the major diameter, and *b' c* the minor, with the distance of *a b* half the major diameter; from the point *c* describe an arc *f d e*, cutting *a b* in the points *f* and *e*. Now assume any point as *g* on the line *b a*, and with the distance *a g* as a radius, from the point *f* as a centre, describe an arc *h h'*, then with the distance *g b* as radius, from

Fig 345

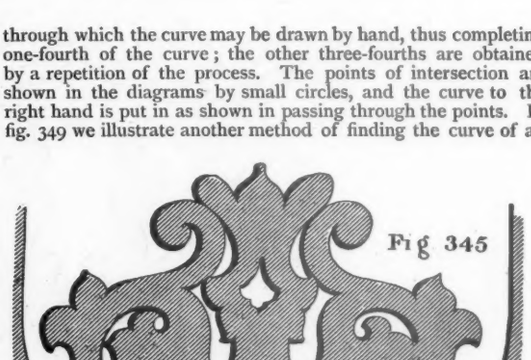
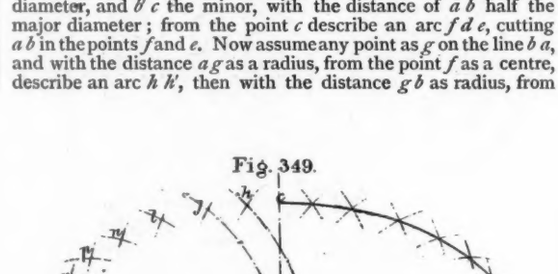
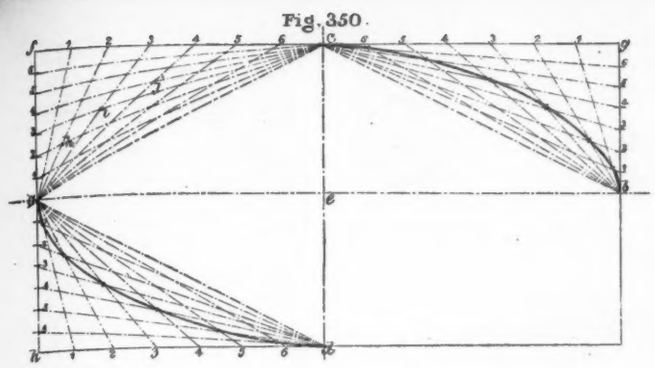


Fig. 349.



the point *e* as a centre, describe another arc, cutting the arc *h*. The first point in the curve will be found, being the intersection of the two arcs in the point *h*. Assume another point on *a b* in the point *i*, then with the distance *a i* as radius, from the point *f* as radius, describe an arc *j b*, then with distance *i b* from point *e* as a centre describe an arc, cutting the other in the point *j*; this will be the second point in the curve. Next assume a third point in *a b* as *k*; and with distance *a k*, from point *f*, describe an arc *l*, and with distance *k b* from point *e* describe another arc cutting this in point *l*, and the third point of this curve will be found. Proceeding thus by assuming points in *a b* as *m o q*, points as *n p r* will be found, and the curve will be drawn through some points by hand. In fig. 350 we give another method of finding the points of an ellipse. Let *a b*, *c d* be the

Fig. 350.



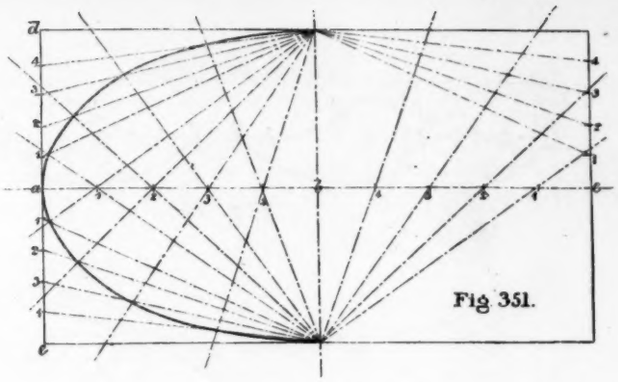
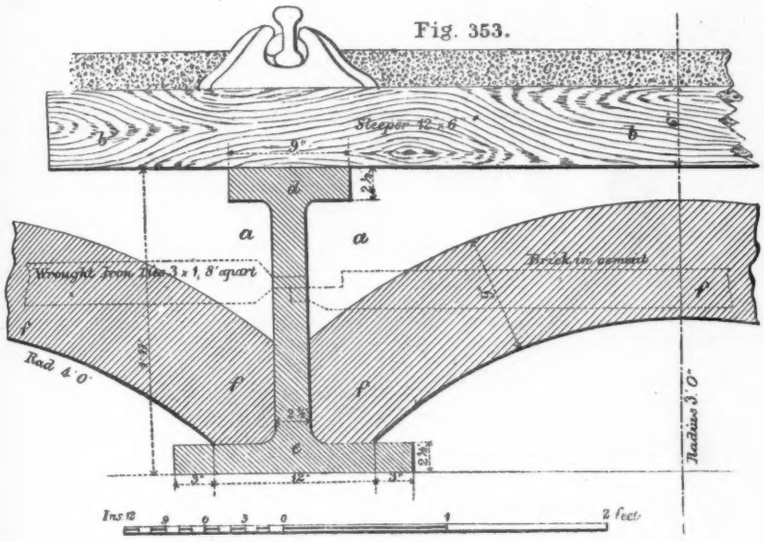


Fig 351.

Fig. 353.



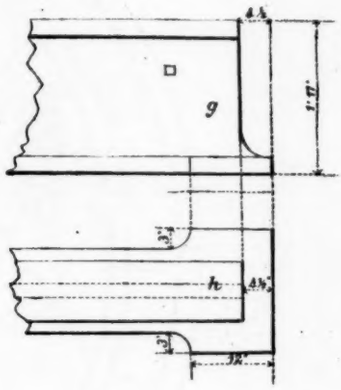
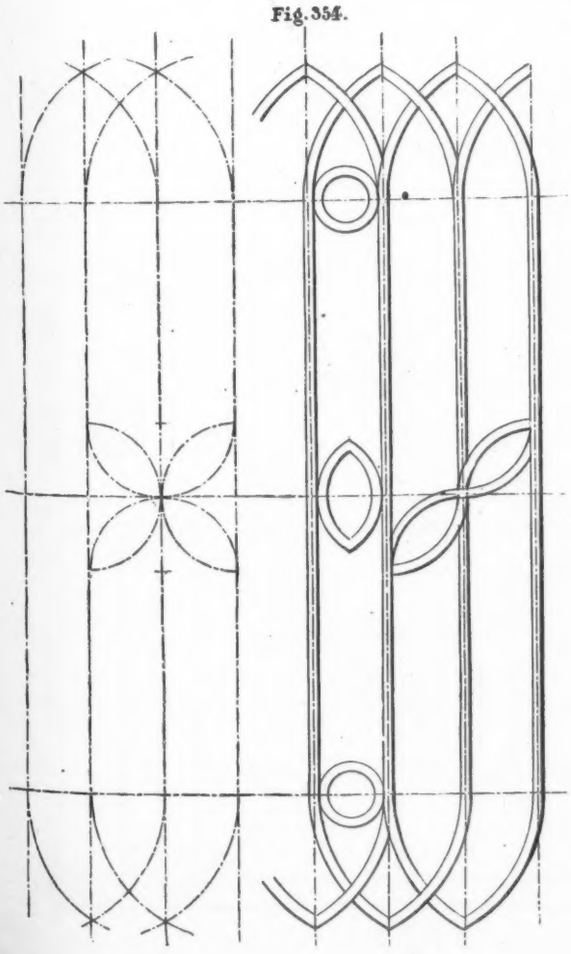


Fig. 354.



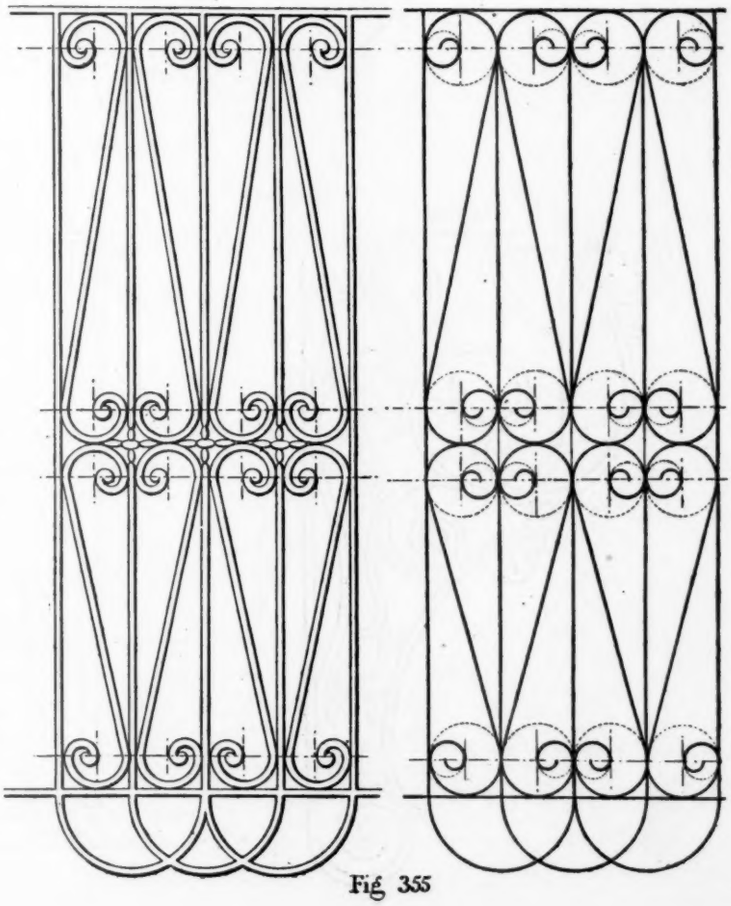


Fig 355

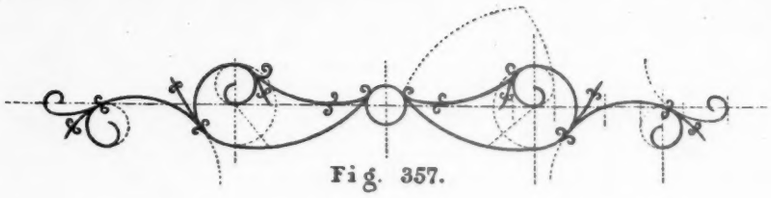


Fig. 357.

Fig. 360.

Fig. 358.

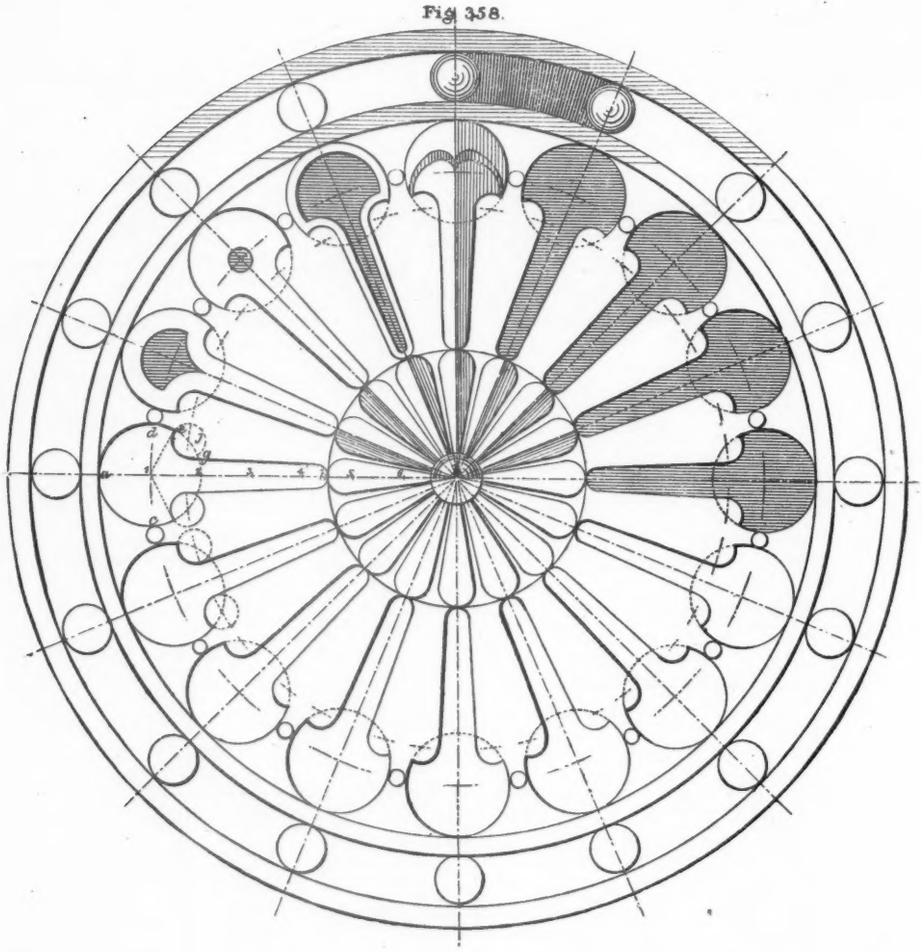


Fig. 361.

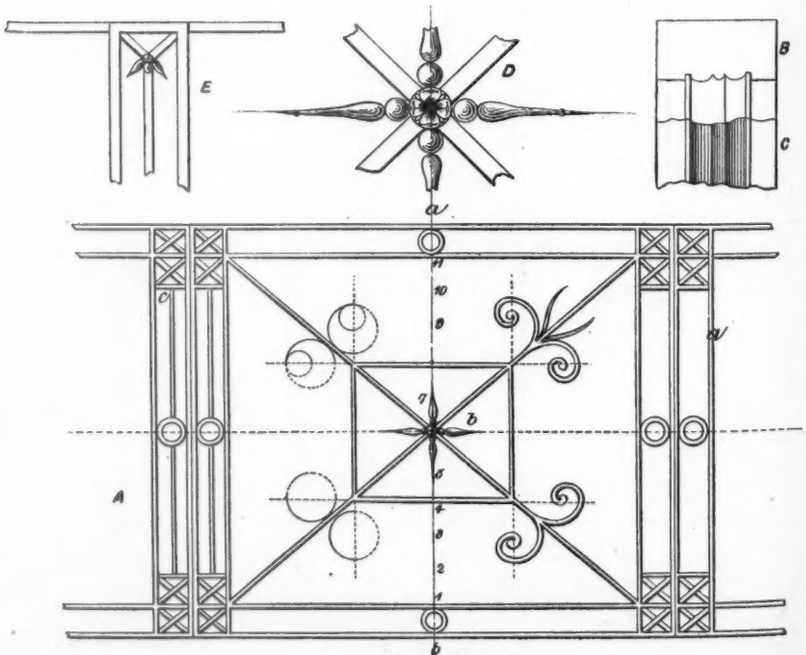
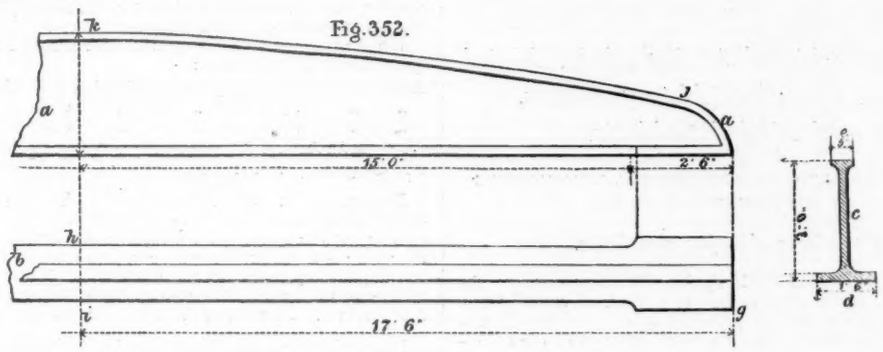


Fig. 363.

Fig. 352.



two diameters intersecting in the point *e*. Through *a b c d* draw lines at right angles to each other, and intersecting at the points *f g h*, and forming a rectangle. Divide the sides *c f*, *f a*, *a h*, *h d*, *d i*, *i g*, and *g c*, each into the same number of corresponding parts, and number them with relation to each other as in the line *c f*, and *f a*. From point *c* through the points in line *f a*, draw a series of lines, and from point *a* through the points in *a f* draw another series. The points of intersection will give a series of points as *h i j*, through which the curve may be drawn by hand. In fig. 351 the rectangular method is in last figure employed, but each half *a b*, *b c* of the major axis is divided into equal parts with the halves of the ends in *a d d e*.

(71.) **The Elements of Iron Construction.**—We take up in this "Note" the subject of cast-iron work, taking the case of beams first. The form most generally adopted now for cast-iron beams is illustrated in fig. 352, in which *a a* is the elevation, *b b* the plan, and *c* the section at centre line. The sectional area of the lower flange *d* is six times that of the sectional area of the upper flange *e*. The width of the bearing as *g* of bottom

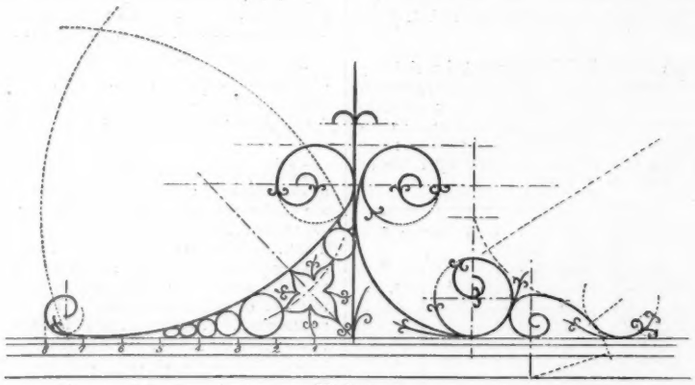


Fig. 356.

flange is not made uniform throughout, but is generally measured as shown at *h i*. In like manner, the height of the beam is less at the bearing end *j*, than at height at the centre, as *k*, the outline of top being generally a parabolic curve as *j k*, but in certain cases of building operations, the top flange of beam requires to be made flat to carry materials; in this case the top and bottom flanges are parallel to one another. The cast-iron beams shown in the illustration are those used for railway

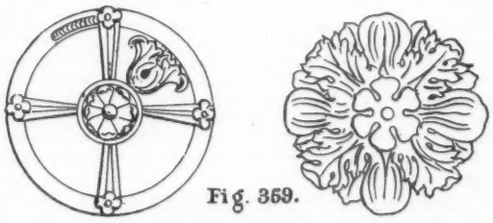


Fig. 359.

work, and were designed for the Great Northern Railway. In fig. 353, we give an illustration showing the method of using cast-iron beams for railway bridge work as designed by Mr. Rastbrick; the system here adopted being almost identical with that used in the construction of fire-proof factories and other buildings, in this latter case the handles or spandrels are filled in with concrete; *b b* represents the flooring beams on which the concrete or other materials forming the floor surface are laid as *c c*. In fig. 353, *d e* represents the section of cast-iron beams which runs across the bridge in a line with the line of railway. The sleepers *b b* running at right angles to these, *f f* the brick arches, *g* the end elevation of beam, *h* plan of bearing of ditto. In a succeeding note we shall give the formulæ for calculating the strength of cast and wrought-iron beams.

Sub-section ornamental work.—We give in fig. 353 and fig. 354 and 355 designs for railing work with working lines and centres shown. In fig. 356 and 357, designs for ornamental

Fig 362.

wrought-iron work for the upper part of railways, gates, &c. In fig. 358 a design for a centre piece, with centre lines marked, in fig. 359 and 360, suggestive designs for ditto. In fig. 361 and fig. 362, designs for brackets, and in fig. 363, a design for a balustrade, in which A is the elevation, B section, and C elevation (full size), of rail as in A. Fig. D enlarged view of part *b* in A, and fig. E, method of finishing the part *c* in A.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

SULPHURIC Acid.—MARTIN patents the employment, in lieu of pyrites, of artificial sulphides of iron prepared by the decomposition of gypsum. Thus a mixture is made of the following constituents :—

Sulphate of lime . .	1700 parts.
Peroxide of iron . .	1000 „
Carbon	500 „

This is introduced into a small blast-furnace; the mass softens, becomes pasty, and runs out at the tapping hole; the calcium salts remain in that part of the furnace designated as "ouvrage."

The iron sulphides thus obtained can be easily roasted. *Bulletin de la Soc. Chim. Paris, xxi.* 47.

[In principle this process seems analogous to the one employed by J. L. Bell for the extraction of sulphur from the "waste" of the alkali maker. *Vide* "Practical Magazine," *vol.* I. *page* 377.—*Chem. Ed.* P. M.]

Percentage of Sulphuric Acid present in dilute Acids of various Densities.—KOLB finds that pure monohydrated sulphuric acid (obtained by addition of sulphur trioxide to the acid as concentrated as is possible by distillation, *i.e.* containing 99·72 per cent. of H_2SO_4) has the specific gravity 1·857 at 0° (Marignac found 1·854), and gives the following table of the density of more dilute acids at 15° :—

Degrees of Baumé's Areometer.	Specific gravity.	Percentage of SO_3	Percentage of SO_4H^2	Degrees of Baumé's Areometer.	Specific gravity.	Percentage of SO^2	Percentage of SO_4H_2
0	1·000	0·7	0·9	34	1·308	32·8	40·2
1	1·007	1·5	1·9	35	1·320	33·9	41·6
2	1·014	2·3	2·8	36	1·332	35·1	43·0
3	1·022	3·1	3·8	37	1·345	36·2	44·4
4	1·029	3·9	4·8	38	1·357	37·2	45·5
5	1·037	4·7	5·8	39	1·370	38·3	46·9
6	1·045	5·6	6·8	40	1·383	39·5	48·3
7	1·052	6·4	7·8	41	1·397	40·7	49·8
8	1·060	7·2	8·8	42	1·410	41·8	51·2
9	1·067	8·0	9·8	43	1·424	42·9	52·8
10	1·075	8·8	10·8	44	1·438	44·1	54·0
11	1·083	9·7	11·9	45	1·453	45·2	55·4
12	1·091	10·6	13·0	46	1·468	46·4	56·9
13	1·100	11·5	14·1	47	1·483	47·6	58·3
14	1·108	12·4	15·2	48	1·498	48·7	59·6
15	1·116	13·2	16·2	49	1·514	49·8	61·0
16	1·125	14·1	17·3	50	1·530	51·0	62·5
17	1·134	15·1	18·5	51	1·540	52·2	64·0
18	1·142	16·0	19·6	52	1·563	53·5	65·5
19	1·152	17·0	20·8	53	1·580	54·9	67·0
20	1·162	18·0	22·2	54	1·597	56·0	68·6
21	1·171	19·0	23·3	55	1·615	57·1	70·0
22	1·180	20·0	24·5	56	1·634	58·4	71·6
23	1·190	21·1	25·8	57	1·652	59·7	73·2
24	1·200	22·1	27·1	58	1·671	61·0	74·7
25	1·210	23·2	28·4	59	1·691	62·4	76·4
26	1·220	24·2	29·6	60	1·711	63·8	78·1
27	1·230	25·3	31·0	61	1·732	65·2	79·9
28	1·241	26·3	32·2	62	1·753	66·7	81·7
29	1·252	27·3	33·4	63	1·774	68·7	84·1
30	1·263	28·3	34·7	64	1·796	70·6	86·5
31	1·274	29·4	36·0	65	1·819	73·2	89·7
32	1·285	30·5	37·4	66	1·842	81·6	100·0
33	1·297	31·7	38·8				

The presence of the small quantities of sulphate of lead usually contained in ordinary acid has no appreciable result on the specific gravity; and the same is true for the sulphurous acid or nitrous fumes also dissolved therein.

100 grammes of dilute sulphuric acid dissolve the following quantities of lead sulphate :—

Acid at sp. gr. 1·841 100 grammes dissolve 0·039 of lead sulphate.
„ „ 1·793 „ „ 0·011 „ „
„ „ 1·540 „ „ 0·003 „ „

Bulletin de la Soc. Mulhouse, 1872, *p.* 209. [*Compare* "Practical Magazine," *vol.* I. *p.* 240.]

Preparation of Phosphoric Acid.—BOVER, LAGRANGE, and CURELY, add to bone ash 60 per cent. of sulphuric acid at 66° B.; water is then added, and after twenty-four hours the whole is filtered: the residue is then washed with water, the washings being saved for the next batch. The cost of concentration is thus avoided, a strong liquor being obtained in the first instance. *Bulletin de la Soc. Chim. Paris, xx.* 574.

Manufacture of Phosphoric Acid and of Phosphates.—STORCK and Co. patent the following processes for this manufacture :—

1st. In order to separate sulphuric acid from phosphates and phosphoric acid, baryta strontia, lead, their carbonates, sulphides, sulphates, hyposulphites, or chlorides, are to be used.

2nd. To prepare tribasic phosphate of ammonia and other phosphates of ammonia, add to an acid phosphate excess of sulphate of ammonia: or remove the impurities and the excess of carbonic acid or sulphuretted hydrogen, by means of baryta, and then pass a current of ammoniacal gas through the liquor, or otherwise saturate with ammonia.

3rd. To prepare phosphate of soda or ammonia, boil the phosphate of ammonia with a slight excess of caustic soda or potash. *Bulletin de la Soc. Chim. Paris, xx.* 480.

Solvay Soda Process.—This process has been at work at Couillet for some time: about one-fourth of the total amount of soda consumed in Belgium is made by this method, for which a diploma of honour was granted at the Vienna Exhibition. *Revue Hebdomadaire*, 1873, *No. xxxviii.*

Manufacture of Soda.—WAGNER states that the process of manufacture of soda ash by the addition to brine of bicarbonate of ammonia, was originally patented in 1838, in England, by Dyar and Hemming, and was abandoned by them. In 1854, Türck took out a French patent for the process, and in the following year Schlœsing did the same. Schlœsing's method was tried for some time in an experimental works at Puteaux, with the aid of apparatus devised by Rolland, but was ultimately abandoned. Improvements were successively suggested by Marguerette and Sourdeval (Paris), Young (Limefield, Scotland), and Solvay (Couillet, Belgium), the last of whom exhibited soda made by this process at the French Exhibition, in 1867. According to Hofmann, this ammonia process is the only one which can enter into competition with Leblanc's method (Vienna Exhibition Reports).

This process is now at work in England, Hungary, Switzerland, Westphalia, Thuringia, Baden, &c., some of the factories turning out a daily production of 300 centners. *Bulletin de la Soc. Chim. Paris, xx.* 522. From *Dingler's Polytech. Journal*, 209, 282.

Soda Manufacture.—RICHE states that there is room for thinking that the production of sulphate of soda by means of sulphuric acid may soon become a process of the past. Not only does the process of decomposition of common salt by bicarbonate of ammonia (thus directly producing soda ash) hold out a fair prospect of success, owing to the improvements of Solvay and others on the original method proposed by Rolland and Schlœsing in 1855; but the process of Balard for extracting sulphate of soda (together with various other salts) from sea-water is one susceptible of large extension, it being even now profitably carried on, notwithstanding the lowered price of potash salts, due to the working of the Stasfurth deposit. *Revue Scientifique*, 1873, *p.* 490.

Ditaine: a new Febrifuge Alkaloid.—GRUPPE states that the bark of the *Echisera Scolaria* contains a bitter non-crystalline principle, to which he gives the name "ditaine." The plant grows in the Philippine Isles, and is employed by the natives as a febrifuge. The alkaloid is extracted in the same way as quinine from Peruvian bark, and is as efficacious as that substance, without possessing the same inconveniences. The bark contains about 2 per cent. of the new base. *Journal de Pharmacie et de Chimie* [4], *xviii.* 225.

Production of Alkaline Carbonates from their Sulphates.—LAWRENCE SMITH adds to five parts of sulphate of potassium dissolved in carbonic acid water, seven parts of

carbonate of barium, and agitates for 4 to 5 hours. Barium sulphate is formed without a trace of residual potassium sulphate, potassium carbonate being produced. *Chem. News, xxvii.* 316.

Transformation of Sulphates, Sulphides, and Carbonates of Alkali Metals into Alkalies.—TESSIE DU MOTAY patents the following process :—The sulphates or other salts are heated on the sole of a furnace covered with lime, magnesia, or dolomite, to the temperature of the fusion of steel or iron. The molten mass then contains the corresponding alkali.

To avoid damage to the furnaces, sufficient lime, magnesia, or dolomite should be employed to form a pasty mass on fusion. Siemens's gas furnaces, or others analogous, should be used, the gases being highly hydrogenized, otherwise the reduction is very incomplete, the decomposition of the salts being due to the action of water in the nascent state.

Sulphides are readily transformed into carbonates by a current of carbonic acid and nascent steam ; the carbonates themselves being decomposed by excess of water, the transformation of sulphides into bases necessarily requires a gas rich in hydrogen. *Bulletin de la Soc. Chim. Paris, xx.* 575.

Superphosphate.—STRIEDTER patents the following process for the direct preparation of monocalcic phosphate :—Sulphuric acid of specific gravity 1·025 to 1·125 is employed, and the whole allowed to settle ; the liquor is then decanted and used directly for the preparation of the higher class of manures. *Bulletin de la Soc. Chim. Paris, xx.* 575.

Production of Alkaline—Earthy Permanganates.—TESSIE DU MOTAY patents the following method :—Caustic baryta is allowed to act on the manganates of soda or potash, whereby barium manganate is precipitated, whilst caustic potash or soda remains dissolved ; by the addition of sulphuric acid, or by means of a current of carbonic acid, barium sulphate or carbonate is formed, and permanganic acid set free. In presence of an alkaline earth, such as magnesia or lime, the permanganate of magnesia or of calcium is thus formed.

Manganate of barium may also be formed by the action of barium hydrate on manganese dioxide at a dull red heat, in presence of a current of air. *Bulletin de la Soc. Chim. Paris, xxi.* 46.

Soap Manufacture.—FOURNIER patents the following process for saving the glycerine set free during saponification :—The fatty matters are firstly converted into a lime soap, or one of similar character ; this lime soap is then treated with potash or soda leys of strength varying with the quantity of lime contained in the soap ; the lime is then thrown down as carbonate, a potash or soda soap being formed instead. *Bulletin de la Soc. Chim. Paris, xx.* 479.

Use of Carbonic Acid to destroy the Causticity of Toilet Soap.—MIALHE patents the subjection of the cakes of toilet soap made in the cold to carbonic acid. About twenty to thirty times their volume of gas is absorbed, whereby the soda becomes converted into bicarbonate. A neutral soap thus results, containing, in addition to the glycerine of the fat, a certain amount of bicarbonate of soda. *Bulletin de la Soc. Chim. Paris, xxi.* 47.

Bleaching Powder.—GOEPNER finds that chlorine has no action on perfectly dry calcium carbonate, but in presence of aqueous vapour carbonic acid is expelled, and calcium chloride and hypochlorous anhydride are formed ; on the other hand, pure lime behaves very differently, but little calcium chloride being formed, this resulting probably either from the presence of traces of carbonate in the lime (or of carbonic acid in the chlorine gas) or from the mechanical carriage of small quantities of hydrochloric acid along with the chlorine.

The bleaching action of bleaching powder is, according to the author, *not* due to the presence of hypochlorite ; hypochlorous acid is *not* formed by the distillation of bleaching powder with aqueous acids, but only a solution of chlorine gas ; an aqueous solution of chlorine is readily distinguished from one of hypochlorous acid, in that the former produces mercurous chloride on agitation with mercury, whilst the latter gives rise to an insoluble crystalline brown oxychloride, together with a little mercuric chloride. This latter could in no case be found by means of the distillate obtained by treating bleaching powder with mineral acids. Even the action of carbonic acid on bleaching powder does not give rise to hypochlorous acid, but only to free chlorine, at least in the first instance ; subsequently, however, a little hypochlorous acid is found in the solution from the reaction of the chlorine first set free on the calcium carbonate formed.

The odour of bleaching powder is simply that of excessively diluted chlorine, being identical with that perceived when a few drops of chlorine water are poured into a large vessel full of air, and the whole agitated so as to obtain a mixture of air and a trace of chlorine.

Dry chlorine does not act on anhydrous quicklime. In practice not only should as much water be added as is required to slack the lime, but also about 8 per cent. more in addition ; more even may be added to obtain the maximum absorption of chlorine, but the extra quantity is far more conveniently added by employing very moist chlorine gas. Ordinary bleaching powder at 38 per cent. can be made to absorb 2·2 per cent. more chlorine by the use of gas washed through warm water. If the water be at 60° to 70°, a bleaching powder is formed containing 42·84 per cent. of chlorine. *Dingler's Polytech. Journal, ccix.* 204.

[The most probable view of the composition of bleaching powder would appear to be that which regards it as a hydrated compound, intermediate between chloride and hypochlorite of calcium, mixed with more or less excess of slacked lime, thus :—

Calcium chloride.	Calcium hypochlorite.	Bleaching powder (anhydrous).
$Ca\begin{cases}Cl.\\Cl.\end{cases}$	$Ca\begin{cases}OCl.\\OCl.\end{cases}$	$Ca\begin{cases}Cl.\\OCl.\end{cases}$

Chem. Ed. P. M.]

The Potash Industry of Stassfurt.—For 1 part of salt ⅔ parts of water are taken, and steam is conducted into the mixture until the solution has acquired a density of 34½° B., after which the liquor is left to stand for about two hours, in order to allow the greatest part of the clay mud suspended in the liquid to settle. The clear, or nearly clear, supernatant solution is drawn off into crystallizing pans. Its constitution varies, especially in the relation of potash chloride to soda chloride, as is seen from the analyses of three different portions :—

	1.	2.	3.
Potash chloride . .	9·65	10·24	9·96
Common salt . .	6·89	6·22	2·48
Magnesia chloride .	14·62	15·73	19·67
Sulphate of magnesia .	4·11	3·74	4·26
	35·27	35·93	36·38

The brine is allowed to cool down in cylindrical iron vessels to 58° C., for the amount of potash salt obtained depends very much on the temperature. The variation in the proportions of the salts which crystallize out at various temperatures is shown in the following table :—

Temperature in centigrade. Degrees.	KCl.	Na Cl.	$MgCl_2$.	$MgSO_4$.	Water.	Percentage of salts in the solution employed.
108—100	3·15	92·78	0·51	0·69	3·95	0·78
100—90	1·35	94·84	0·78	0·69	2·24	0·61
90—80	1·63	95·61	0·83	0·57	2·65	0·47
80—70	0·86	96·64	0·58	0·43	2·25	0·50
70—60	3·70	92·70	0·76	0·63	2·68	0·40
60—50	25·16	70·56	0·12	0·72	3·04	0·57
50—40	72·01	23·49	0·32	0·50	3·11	1·91
40—30	75·75	19·07	0·87	0·42	3·76	1·16
30—20	74·51	21·05	0·80	0·89	2·15	1·03
20—10	25·77	8·62	1·42	29·46	34·62	2·25
10—0	11·91	7·18	3·34	36·77	40·93	4·88

The solution employed in the above trials had the constitution of the mineral quoted under analysis 3.

Another portion, cooled 55½° C., below, yielded :—

Temperature in centigrade.	KCl.	Na Cl.	Mg Cl.	$MgSO_4$.	Water.	Percentage of salts in the liquor employed.
55½—19	81·36	13·07	1·02	0·30	3·84	5·96
55½—17½	81·10	12·93	0·99	0·33	3·88	5·86
55½—15	82·91	11·77	0·91	0·33	4·76	6·36
15—11½	56·99	38·39	1·09	0·37	2·62	1·18

Thus the above tables make it obvious that potash chloride separates between 60° and 50°, and that between 20° and 10°, an additional separation of common salt takes place.

If the raw material is dissolved not in water, but in the mother liquors remaining after the first crystallization, the solution has, at 100°, and at a density of 1·273, the following composition:—

Potash chloride	12·28 per cent.
Common salt	4·97 „
Magnesia chloride	17·93 „
Sulphate of magnesia	2·28 „
	37·46 per cent.

The proportions of potash chloride crystallizing out from this solution at various temperatures are as follows :—

Temperature in centigrade.	Potash chloride.	Water.	Percentage of salt in the lye.
98—90	6·61	16·67	1·12
90—80	3·45	4·19	0·38
80—70	24·64	3·07	0·61
70—60	76·92	4·19	1·03
60—50	78·52	5·38	1·50
50—40	80·40	4·75	1·46
40—30	94·57	3·50	1·23
30—20	68·50	2·96	2·03
20—15	86·71	2·42	0·52
15—10	87·54	2·97	0·81

From the first cooling vat the mother liquors pass, after the separation of the first batch of potash salt, into concentrating pans heated over an open flame. Comparative trials have shown that mother liquors from water solutions yield less constant results than those solutions which are obtained by dissolving the raw salt in the first mother liquors; by concentrating the latter lyes to 35° B. density the largest amount of potash salt is gained.

The residual salts, which cannot be advantageously worked for the extraction of potash, are chiefly turned to use as a mineral addition to manures. This part of the Stassfurt industry dates from 1864. The sudden great demand for this salt (best known in England under the name "Kaïnite") arose from the publication of the wonderful results which the experiments of Frank produced at the agricultural station of Waldau.

The last mother liquors are in some places used for the manufacture of bromine. They are for this purpose treated in stone pans with acids and manganese, and the bromine set free is collected through leaden pipes (cooled) dipping first into water and then into caustic alkali.

Where no bromine distillation is carried on, the last mother liquors are evaporated in flat pans over the open fire to dryness, the dry residue heated to melting and cast into blocks or cakes. These blocks, containing about 55 per cent. of magnesia chloride, come mostly to England, where they find application in cotton mills. [*From a paper by Th. Becker in Dingler's Polytech. Journal.*]

§ 2. *Metallurgy.*

Tempering Steel.—KULICKE suggests the following process, which is employed at Saarbrück. The steel which has lost its temper, or which is "burnt," is heated to a cherry-red heat, dipped for an instant in the following mixture, and then immersed in cold water :—

Tartaric acid	12 parts
Fish oil	60 „
Charcoal powder	4 „
Bone black	16 „
Suet	20 „
Ferro-cyanide of potassium	20 „
Incinerated stags' horns (hartshorn?)	6 „

Tools that have lost their temper, such as saws, chisels, &c., can be restored by this means. *Bulletin de la Soc. Chim. Paris, xx.* 474.

Blue Iron Slag.—J. R. MCDIRBY gives the following analysis of a sample of pure blue slag from Barrow; the tint was so fine that a specimen cut *en cabochon* made a handsome stone for a finger ring, comparable in tint with the darker qualities of *lapis lazuli* :—

Sp. gr. 2·883.

Silica	46·683
Alumina	5·769
Ferrous oxide	1·208
Manganous oxide	1·062
Lime	39·168
Magnesia	0·987
Potassium oxide	0·967
Sodium oxide	1·276
Sulphur	2·074
	99·194

Chem. News, xxviii. p. 272.

Phosphor Bronze.—MONTEFIORI, LEVI and RUENZEL, having found that the tenacity of bronze is much increased by the addition thereto of phosphorus (as copper phosphide), the following experiments have been made on the subject.

The Technological Academy of Berlin give the following results obtained by means of a machine, whereby the bar examined was subjected to a known constant tension for a large number of times successively until rupture occurred :—

	Tension per sq. in. in centners.	Number of repetitions of tension preceding rupture.	Observations.
Phosphor bronze, No. 1.	200	408,230	The ruptured surface resembled molten steel.
„ „ No. 2.	250	147,850	—
„ „ No. 3.	150	—	Bore 480,000 extensions without breaking, lasting from April 23rd to May 17th, 1873.
Ordinary bronze, No. 1.	200	—	Broke before a tension of 200 centners was reached.
„ „ No. 2.	200	4,200	Irregular fracture.

By means of another machine where the bar, subjected to a known force of traction, was repeatedly bent and unbent at the rate of 40,000 flexions a day, the following numbers were arrived at :—

	Tension per sq. inch.	Number of flexions before rupture.	Observations.
Phosphor bronze, No. 1.	200	862,980	Rupture only took place across the drawn-out fibres, not along the neutral axis.
„ „ No. 2.	180	—	Bore 1,260,000 flexions before rupture, lasting from March 15th to May 19th, 1873.
„ „ No. 3.	150	—	Bore 212,000 flexions, from May 3rd to May 19th.
Ordinary bronze, No. 1.	200	102,650	Regular fracture; the rupture in the first instance was not due to bad quality of metal. Complete rupture.

UCHATIUS has obtained the following absolute resistance of a special quality of phosphor bronze made for firearms :—

	Absolute resistance per square centimetre.	Limit of elasticity per square centimetre.	Lengthening in percentage of original dimensions.
Phosphor bronze, No. 4	3,600—3,340 kil.	600— 400	20·66—14·66
Phosphor bronze, No. 5	5,660—5540 „	3,800—2,800	1·6 — 2·26
Krupp's steel	5,000 „	1,000	11
Bronze: gunmetal	2,200 „	385	15

KIRKALDY gives the following values :—

	Tension in lbs. per square inch.		Percentage lengthening at moment of rupture.
	Not annealed.	Annealed.	
Copper wire	63,122	37,002	34·1
Iron wire (good) . . .	65,834	46,160	28·0
Steel	120,976	74,637	10·9
Phosphor bronze, No. 1.	159,515	58,853	46·6
" " No. 2.	151,119	64,569	42·8
" " No. 3.	139,141	54,111	44·9
" " No. 4.	120,957	47,787	34·1
" " No. 5.	120,950	53,381	42·4
" " No. 6.	102,739	49,351	37·5

Sea water affects phosphor bronze much less than ordinary bronze ; thus the following results were obtained after six months' exposure:—

	Percentage loss of weight.
Ordinary bronze	3·058
Phosphor bronze	1·158

Bulletin de la Soc. Chim. Paris, xx. 474. From *Deutschen Industrie Zeitung*, 1873, *No. xxxii.; also Dingler's Polytech. Journal, ccix.* 186.

Pulverulent Gold.—WEISSKOPF converts 3·5 grammes of gold into neutral chloride, and dissolves in 750 ccs. of water ; a solution of 12 grammes of caustic soda in 200 ccs. of water, and one of 0·5 grammes of starch-sugar or milk-sugar in 6 ccs. of water are also prepared ; to the latter is added its own volume of alcohol and the same of aldehyde. All the liquors are then mixed and left in the dark for a quarter of an hour, at the end of which time the gold is deposited as a finely divided black powder ; this is decanted, washed with water, and dried at a gentle heat. *Polytech. Notizblatt, xxviii.* 285.

Tellurium Ores.—FRIEDEL finds that a telluride of gold and silver from Kara Hissœr, in Asia Minor, contains :—

Tellurium	24
Silver	37
Gold	27
Sulphide of zinc } Sulphide of lead }	12
	100

Bulletin de la Soc. Chim. Paris, xx. 481.

New Bismuth Ores.—CARNOT describes the following ores from Meymac, in the department of Corrèze :—

Native Bismuth : Fracture, crystalline, and brilliant with the ordinary bright lustre.

Bismuth Sulphide : Texture fibrous, slightly bluish black, containing a little lead, iron, antimony, and arsenic.

Bismuth Oxide or Hydrocarbonate, derived from the alteration of the sulphide, the fibrous structure of which is preserved.

Antimonial Bismuth : Grey tint and metalloid appearance, containing a little lead, arsenic, sulphur, &c.

In addition to these, the following minerals have also been found :—

Mispickel containing small quantities of antimony, bismuth, and lead.

Carbonate of Lead } Appearance as usual.
Sulphate of Lead }

Molybdate of Lead : Small tabular crystals.

Wolfram : Brilliant and easy cleavage, containing more tantalic acid than is usual.

Tungstate of Lime : Lamellar masses of a brownish grey tint and fatty lustre.

Hydrated Tungstic Acid : Sometimes of a clear yellow shade, sometimes waxy: appears to be formed by the alteration of tungstate of lime by sulphuric acid from the oxidation of pyrites. *Bulletin de la Soc. Chim. Paris, xx.* 487.

Arsenic in Crude Cast-Iron.—MITTEREGGER found the following constituents in a light grey cast-iron :—

Graphite	1·300
Carbon (chemically bound) .	0·955
Silicon	0·648
Phosphorus	0·440
Arsenic	1·012
Manganese	0·722
Copper	0·133
Calcium	——

A specimen of white cast-iron, from which graphite, separated on cooling, consisted of :—

Graphite	8·800 (?)
Carbon (chemically bound) .	1·555
Silicon	0·576
Phosphorus	0·015
Arsenic	1·290
Manganese	0·759
Copper	0·029
Calcium	0·050

A white cast-iron, which eliminated no graphite, was composed as follows :—

Graphite	0·550
Carbon (chemically bound) .	1·925
Silicon	0·192
Phosphorus	0·041
Arsenic	1·698
Manganese	2·020
Copper	0·119
Calcium	0·075

These figures show that the amount of arsenic is nearly proportional to that of chemically bound carbon, whilst the quantity of silicon decreases in the like proportion.

BERTHIER found in shells from an arsenal in Algeria 27·0 per cent. of arsenic. *Kärnthner Zeitschr.; through Polytech. Centralblatt.* 1873, 338.

The Iron Trade of the Austro-Hungarian Empire.—In a recently published statistical account of the Austro-Hungarian iron industry, the following figures are given relating to the import, export, and consumption of iron in the twenty-four years from 1848 to 1871 :—

Year.	Production.	Import.	Export.	Consumption.
	Cwts.	Cwts.	Cwts.	Cwts.
1848	3,865,038	25,616	266,801	3,623,843
1849	3,784,460	16,792	358,942	3,443,310
1850	3,911,173	78,131	431,644	3,557,660
1851	4,045,144	99,484	441,084	3,703,544
1852	4,185,313	459,192	378,268	4,266,237
1853	4,833,939	900,594	351,118	5,383,415
1854	5,093,721	440,165	313,064	5,220,822
1855	5,505,544	597,257	407,570	5,695,231
1856	5,750,434	1,422,809	466,076	6,707,167
1857	6,356,039	2,633,360	446,963	8,542,436
1858	6,669,506	3,871,843	497,808	10,043,541
1859	6,346,837	1,473,358	564,406	7,255,789
1860	6,251,098	934,109	582,217	6,602,990
1861	6,318,459	582,380	678,822	6,222,017
1862	6,964,862	695,945	721,709	6,939,101
1863	7,131,788	827,156	594,937	7,364,007
1864	6,380,566	803,317	647,167	6,536,716
1865	5,847,263	684,125	606,367	5,925,021
1866	5,692,778	326,084	757,165	5,261,697
1867	6,398,058	656,059	924,370	6,129,747
1868	7,501,542	5,492,274	727,464	12,266,352
1869	8,108,658	8,990,210	729,591	16,362,277
1870	3,223,578	9,130,363	624,610	16,729,323
1871	8,634,097	9,891,295	691,520	17,833,872

Electro-deposition of Tin.—T. FEARN claims improvements in the electro-deposition of tin, which consist mainly in certain special solutions with particular specialities in their temperature when used, and in the degree of battery-power employed. The main solution is that of the perchloride of tin ; which is mixed in various proportions with one of the following liquors :—1. a mixed solution of hydrate of potash, cyanide of potassium, and pyrophosphate of soda ; 2. A mixed solution of pyrophosphate of soda and muriate of ammonia ; 3. A mixed solution of the hydrate and tartrate of potash ; and 4. A simple solution of muriate of ammonia.

§ 3. *Dyeing, Calico Printing, Tanning, Bleaching, and allied subjects.*

Preparation of Linen for Aniline Black.—The goods are plunged alternately for 10 minutes into the two following baths :—

No. 1.

Tannin	1 part
Water	500 „

No. 2.

Glycerine	1 part
Water	32 „
White of egg	quant. suf.

For delicate shades bath No. 2 may be used alone. *Reimann's Färberzeitung*, 1873, *No. xxxvi.*

Nicholson Blue.—Woollen goods should be worked in a 1 per cent. solution, ¼ per cent. of zinc sulphate being added, the temperature being gradually raised up to boiling. The whole is boiled for an hour. The cooled goods are rinsed in cold water and placed in a 2 per cent. sulphuric acid solution, containing ½ per cent. zinc sulphate. *Reimann's Färberzeitung*, 1873, *No. xxxvi.*

New Colouring Matters.—CROISSANT and BRETONNIERE patent a process for the transformation of organic bodies into colouring matters, whereby many refuse products can be utilized, such as sawdust, vegetable humus, bran, starch, gluten, mosses, cotton and paper refuse (cellulose), tannin, aloes, &c. The materials are heated with sulphur at a high temperature, whereby dehydrogenation takes place, sulphur derivatives being formed.

Thus, to convert bran into dyestuff, the material is placed in an iron vessel provided with a lid, caustic soda and flowers of sulphur are then added, forming a homogeneous paste; this is placed in a stove or in a furnace, and heated to 250° or 300°. An alkaline sulphide is first formed, and this reacts on the organic body, sulphuretted hydrogen being evolved, and a sulphuretted mass being formed. This is soluble in water, communicating thereto a fine liver-green colour. The solution has an alliaceous odour, and dyes fibres (silk, wool, or cotton?) without a mordant.

Various shades may be prepared from the same materials by slightly varying the proportions. Some bodies, such as aloes, produce colouring matters at a boiling temperature, whilst others require more heat. Thus, for example :—

Aloes	3 kilos.
Caustic soda solution at 40° B.	10 litres
Water	10 „
Flowers of sulphur	3 kilos.

By heating this at a boiling heat a lilac grey product is formed. By pushing the action further, dark brown dyes :—

Humus	20 kilos.
Normal sulphide	40 litres

This *normal sulphide* is made as follows :—

Caustic soda ley at 40°	70 litres
Water	65 „
Sulphur	30 kilos.

To dye cotton or linen the requisite amount of product is dissolved in water at 60°, and the goods passed through the bath as usual. They are then passed through boiling potassium dichromate solution, which fixes the colour, rendering it insoluble in water. *Bulletin de la Soc. Chim. Paris, xxi.* 41; *Moniteur de la Teinture, Oct.* 20, 1873.

Salmon Colour for Woollen Goods.—A yellow bottom is given by means of *terra merita* or Cuba wood; and subsequently the goods are passed through a weak fuchsine bath acidified with acetic acid.

For silks, two baths may be used, one of rocou, the other of safranine (the latter in very small quantity). *Bulletin de la Soc. Chim. Paris, xxi.* 43; *Moniteur de la Teinture, Nov.* 20, 1873.

Logwood Blue on Wool.—Boil the goods (150 parts by weight), in liquor made from—

Yellow potassium chromate	3 parts
Sulphate of copper	1 „
Sulphuric acid	2 „

Boil for an hour, and then allow the goods to lie all night in this bath. Dye next day with a bath of—

Logwood	15 parts
Tartar	9 „
Coarsest neutral indigo extract	12-13 „

Reimann's Färberzeitung, 1873, *No. xlii.*

Woollen Dyeing with Zinc.—To prepare a vat holding 500 litres, take—

Soda crystals	30 parts
Ground indigo	2 „
Powdered zinc	15 „
Ammonia	15 „
Carbonate of ammonia	1½ „

Dissolve the soda in water, add the indigo and zinc, stir up, add the ammonia and carbonate, and stir again and allow to settle : before use the liquor should be heated to 40° to 50° R (50° to 62·5° C.)

To renovate the liquor, add for every part of indigo—

Zinc powder	½ parts
Soda	2 „
Ammonia	1 „
Carbonate of ammonia	6¾ „

Reimann's Färberzeitung, 1873, *No. xlii.*

Substitute for Tartar in dyeing Woollens.

Solution No. 1.

Alum	10 kilogrammes
Water	40 litres

Solution No. 2.

Oxalic acid	35 kilogrammes
Hot water	20 litres
Acetic acid	2 kilogrammes

Mix. The liquor effects a saving of 50 per cent. as compared with tartar. *Reimann's Färberzeitung*, 1873, *No. xxxix.*

Brown on Shoddy containing Cotton.—(VELOUR.) For 100 parts of goods, use—

Fustic	30 parts
Alum	3 „
Prepared tartar	2 „
Blue vitriol	1 „

Boil half an hour, and add to the liquor 1 part potassium bichromate, and ¼ parts of aniline red (fuchsine, roseine, rubine). Boil very gently; darken with logwood, or alter shade with turmeric if required. *Reimann's Färberzeitung*, 1873, *No. xxxix.*

Marine Blue for Silks.—This tint is obtained by means of the ordinary aniline blues, which need not be of the finest qualities (bleus lumières), mixed with about half their weight of a blue black. *Moniteur de la Teinture, Nov. 20th*, 1873.

Blue Black on Cotton.—GIRARD states that by the use of diphenylamine in lieu of aniline, he can directly obtain a blue-black tint on cotton goods. The sodium or ammonium sals of the conjugated sulpho-acids of diphenylamine should be used. *Bulletin de la Soc. Chim. Paris, xx.* 481.

Safflower Rose on Glazed Calico.—The following dressing is recommended :—

Wheat starch	50 parts
Wheat flour	20 „
White wax	4 „
Cocoanut oil	6 „

Mix the starch with water containing a little sulphuric acid. *Reimann's Färberzeitung*, 1873, *No. xxxix.*

Violet on Woollen Yarn.—Work the bleached yarn in the following mordant :—

Tannic acid	1½ parts
Marseilles soap	½ „
Rape oil	¼ „

Dissolve the soap in hot water, then the tannic acid, add the oil and stir till an emulsion is formed. Work the yarn fifteen minutes, and pass into the dye-beck, made as follows :—

Alum	5 parts
Methyl violet	1 „

Both baths should be at 60° R. (75° C.) *Reimann's Färberzeitung*, 1873, *No. xxxix.*

Coralline.—COMMAILLE finds—1. That this dyestuff can be obtained at temperatures varying from 115° to 150°. In the first case the yield is greater and the operation quicker.

2. The quantity of oxalic acid usually prescribed is too large.

3. Coralline does not form definite salts, only lakes or compounds similar thereto.

4. *Yellow* coralline is not an acid at all; the term rosolic acid is a misnomer.

5. *Red* coralline contains no nitrogen, and is therefore not an amide of yellow coralline. *Comptes Rendus, lxxvii.* 678.

Dialyzed Ferric Oxide as a Mordant.—Instead of acid solutions of iron, which exert an injurious action on the

strength of the fibres of silk and other goods, the soluble hydrated ferric oxide obtained by Graham's process (dialyzing a solution of ferric chloride, when hydrochloric acid passes away, soluble ferric hydrate being left) may be employed with advantage. This liquor yields iron to the silk with ease without in any way injuring it. Its activity as a mordant is far greater than that of ordinary iron salts, not being influenced by the presence of acid. In point of fact, the utility of ferric salts as mordants may be attributed to the fibres of the goods themselves acting as dialyzers, whereby a film of ferric hydrate is formed on them, the acid remaining free in the bath.

OLTMANNS (Hanover) has for some time prepared for this purpose a solution containing from 6 to 7 per cent. of pure ferric oxide.

In order to quicken the dialyzing process, a solution of ferric chloride in which ferric oxide is dissolved, may be advantageously employed, *i. e.* a ferric oxychloride or hydrato-oxychloride. *Dingler's Polytech. Journal, ccix.* 464.

Quick Tanning Process. — LIAUTARD inflates the skins with pure carbonic acid, introduced under pressure into the vessels containing the skins; these vessels are heated by means of an outside jacket. When the expansion of the skins is sufficient, a mixture is introduced of—

Ammonia	5 centilitres
Chloride of lime . . .	5 „
Acetate of lead . . .	a few drops

per cubic metre of water contained in the vats.

This operation suffices for goat, sheep, and calf skins; for tough leathers the skins must be passed through the trenches. *Bulletin de la Soc. Chim. Paris, xx.* 478.

Depilatory for Skins.—WATTEAU patents the use of a mixture of the sulphides of calcium and sodium prepared by boiling together for five or six hours the following substances :—

Water	4,800 litres
Sodium carbonate . .	430 kilogs.
Caustic lime	630 „
Sulphur	140 „

After cooling, the liquor is applied to the flesh side of the skin; in two hours wool is readily detached from a sheepskin, for instance. *Bulletin de la Soc. Chim. Paris, xxi.* 46.

Ammoniacal Soap.—ROHART patents the use of ammoniacal soap for cleansing raw or manufactured wool from grease; a softness and whiteness is thereby produced, not caused by the ordinary soda or potash soaps.

Putrified urine may be advantageously employed as a cheap source of ammonia : this is neutralized by an acid, and added to the soda or potash soap ley until no more coagulum floats up to the surface; this scum is removed and drained, dried, and pressed; it constitutes an ammoniacal soap; when required for use it is dissolved in water containing 1 to 2 per cent. of carbonate of soda. *Bulletin de la Soc. Chim. Paris, xx.* 573.

[*Compare* "Practical Magazine," *November*, 1873, *p.* 373.]

Bisulphite of Sodium as Antichlore in Bleaching.—SCHUCHARDT states that hyposulphite of soda has the disadvantage of causing a deposit of finely divided sulphur in the pores of the fibre, and is for that reason occasionally inconvenient; a solution of bisulphite of sodium on the other hand is free from this defect. *Bulletin de la Soc. Chim. Paris, xxi.* 43; *Moniteur de la Teinture, Nov.* 20, 1874.

Poisonous Green Paint for Ships' Bottoms.—CHARTIER patents the use of the following mixture:—

Suet in small fragments . .	20 kilogs.
Crystallized verdigris . . .	3 „
Picric acid in grains . . .	1 „
Blue mixed up with oil . .	0·030 „

500 grammes of corrosive sublimate, or some other mercurial salt, may be used instead of the verdigris.

The whole is to be worked up into a compact malleable paste, and then reduced to a fine powder. *Bulletin de la Soc. Chim. Paris, xx.* 573.

§ 4. *Food and Sanitary Matters.*

Preservation of Meat.—DUBOUCH patents the following process:—Instead of separating the hide of the recently killed animal by blowing air into the subcutaneous tissue, he employs carbonic acid, nitrogen, hydrogen, etc. The carcase is then cut up, and the joints thrown into drums containing molten fat, butter, glycerine, &c.; the cases are then heated to 120° or 130°, and sealed up; or superheated carbonic acid may be used to displace the air. *Bulletin de la Soc. Chim. Paris, xx.* 478.

Determination of Alcoholic Strength of Spirituous Liquors.—BROSSARD-VIDAL and MALLIGAND patent the use of an ebullioscope, based on the boiling points of various mixtures of water and alcohol; it is graduated in hundredths of a per cent. up to 30 per cent. of alcohol, being intended for the examination of wines. The graduation is effected by determining the point of ebullition of mixtures of exactly known density. The alcoholic strength is given by the length of the column indicated by the ebullioscope; the degrees are indicated in half millimetres, and the apparatus is accompanied with an empirical table giving the corresponding richness in alcohol.

At 15° the following values are given for the specific gravity of mixtures of alcohol and water, varying from 1 to 19 per cent. of alcohol :—

Per cent. of alcohol.	Specific gravity.	Per cent. of alcohol.	Specific gravity.
1	0·991669	11	0·921585
2	0·985845	12	0·910258
3	0·980412	13	0·898255
4	0.975262	14	0·886075
5	0·970042	15	0·873695
6	0·960915	16	0·860719
7	0·957666	17	0·846838
8	0·949925	18	0·831865
9	0·941366	19	0·815956
10	0·931956		

Bulletin de la Soc. Chim. Paris, xxi. 575.

[In this account of the instrument, it is not stated whether any corrections are to be made for alterations of barometric pressure during the various determinations made with it; nor what corrections are made for the influence on the boiling point of dissolved matter in the wine (sugar, colouring matter, tartar, &c.), or of volatile compound ethers.]

New Process for the Manufacture of Beer that will Keep.—PASTEUR has made an examination of the causes which promote the deterioration of beer, and finds that this change results from the development of microscopic organisms, which may be termed "ferments of beer-sickness" (*ferments de maladie*). The germs of these organisms come from the air, &c. To make beer keep indefinitely, all that is required is to prevent them from coming in contact with the liquid. This is accomplished by using a peculiar yeast, freed from all kinds of foreign germs.

The process whereby this pure yeast is obtained in the first instance is not stated; having been once obtained, it can be multiplied to any extent by fermentation.

The wort is cooled in the fermenting vat either by the air or by a current of water. If the entrance of air is to be avoided, a current of carbonic acid gas is let in by one vertical tube, another removing the excess. Under these circumstances the wort will remain unchanged for an indefinitely long period; by the addition of a little pure yeast, fermentation is set up; but care must be taken that the yeast is excessively pure, as the germs of sickness develop much more readily in an atmosphere deprived of oxygen than in the air, the true yeast plant being oppositely affected by the air.

The fermenting vat employed when the entrance of air is avoided, is made of tinplate, covered by a water-lute, so that communication can only be made between the interior and exterior by means of the pipes whereby the carbonic acid enters and leaves the tube. The operation may be conducted at a temperature of 20° to 25°. *Comptes Rendus, lxxvii.* 1140.

Iron in Tea.—BIRD states that the iron occasionally found in tea, and communicating to it the power of being attracted by the magnet, is very probably derived from magnetic oxide of iron occurring as dust in the soil in which the tea plant grows. French bean leaves, grown in England, were found by him to be attracted by the magnet, and to contain 0·2 per cent. of magnetic oxide of iron, which was also found in the mould of the garden, where the bean plants grew. *Chem. News, xxvii.* 256.

M. WILLIAMS considers that "facing" tea with a material not injurious to health, and the object of which is simply to cause a darker colour, is no more an adulteration than the practice of facing or altering the appearance of silk, &c. by dyeing (!)

Iron filings would be far too costly for extensive use for this purpose; but hematite is plentiful in China. Any iron compound

has more or less tendency to form a black product by its action on the tannin present. *Ibid. p.* 259.

A. H. ALLEN states that he has found iron in a form soluble in water in tea, apparently added as sulphate of iron, a mode of procedure apparently too scientific in character to have emanated from "the heathen Chinee." Inasmuch as the popular notion of the strength of tea is founded on the depth of colour of the infusion, the addition of anything that deepens this colour gives a fictitious strength, and is quite unjustifiable, besides being probably injurious to health. *Ibid. xxviii.* 276.

Use of Carbolic Acid in Sugar Manufacture.—CUNISSET patents the employment of carbolic acid or of its compounds with alkalies, or mingled with substances in which it is soluble as a preservative of beetroot juice (!) *Bulletin de la Soc. Chim. Paris, xxi.* 47.

Destruction of Phylloxera.—TESSIE DU MOTAY patents the use of the following methods, which produce nascent sulphur either on the plant itself or in the soil :—

1. Watering the plant with a solution of an alkaline hyposulphite; and, after the solution has reached the roots, with another solution of acid phosphate of lime.
2. Sulphydrates or sulphides are used in lieu of hyposulphites and a solution of bisulphite of soda in lieu of acid phosphate of lime. *Bulletin de la Soc. Chim. Paris, xxi.* 48.

Prevention of Impregnation of Water by Lead.—WILLM finds that leaden pipes covered internally with a layer of sulphide of lead (produced by the action of sulphide of sodium), are much less readily attacked by rainwater, melted snow, distilled water, &c., &c., than the same pipes when not protected in this way. Tubes 50 centimetres long were thus prepared and examined in conjunction with others not thus protected, but carefully rinsed out : after one day, the unprotected tubes communicated a perceptible quantity of lead to rainwater, melted snow, and distilled water, but the result was only produced after some days with the ordinary Paris service water. The protected tubes, on the other hand, communicated no trace of lead to water, even to rainwater, after three months' contact in presence of air. *Bulletin de la Soc. Chim. Paris, xx.* 529.

Maternity Institutions.—BOUCHARDAT states that the researches of Leon le Fort show that taking together the maternities and hospitals in France, and the rest of Europe, the average number of deaths is 1 in 29 cases of childbirth, whereas 1 in 212 is the average in the cases not treated in institutions of the kind. The evil effects of thus collecting together a large number of women in childbed is apparent; periodical epidemics of a deadly puerperal peritonitis occur, thereby greatly increasing the death rate; thus at the Maternité, in 1864, the death rate was 1 in 5·03 ! The desirability of affording assistance to poor women in childbed *at home*, or at least in separate houses or cottages, instead of Maternities and hospitals, cannot be too strongly urged. *Revue Scientifique*, 1873, *p.* 561.

Evil Results of Collecting Together a large Number of Patients and Sick People.—BOUCHARDAT gives the following statistics, among many others, all tending to show how the massing together of a large number of invalids is productive of injury, from the increased tendency to "hospital gangrene," and analogous complaints :—

Amputation of the thigh (*Bristow and Holmes*).

	Mortality.
London hospitals	36 per cent.
Hospitals in provincial towns	34·5 „
Rural hospitals	24 „

Amputations generally (*Simpson*).

	Death rate.
London hospitals	1 in 3
Provincial towns	1 in 4
Rural	1 in 5·5

Amputation of the thigh (*Callender*).

	Mortality.
St. Bartholomew's hospital 1853-1868	34·3 per cent.
Provincial hospitals	27·6 „
Private practice (London excluded)	18·5 „

Influence of the number of patients in the hospital.

	Mortality in cases of amputation of the thigh.
Hospitals with less than 100 patients	25·3 per cent.
„ 100 to 200	30·7 „
„ 200 to 400	37·5 „
„ above 400	40·0 „
Parisian hospitals	74 „

From some unexplained cause, the French method of treatment in amputation cases appears to give less favourable results than those adopted by other nations; thus the following numbers are quoted from the results obtained in different armies :—

	Death rate in cases of amputation of the thigh.
English army (Crimea)	64 per cent.
French „ „	91·8 „
American „	64·4 „
French „ (Italy)	76·4 „

Revue Scientifique, 1873, *p.* 588.

§ 5. *Fuel, Gas, Illumination, Photography, &c.*

New Fuel.—PAGLIANI manufactures a combustible mixture to be used as fuel as follows :—

Distilled petroleum	20 kilogs.
Resin	30 „
Coal dust	40 „
Charcoal dust	30 „
Sawdust	6 „
Sulphate of calcium	10 „
	136

The resin is dissolved in the petroleum, heated to about 70 by steam, then the other substances added gradually. After thorough mixture the whole is run into moulds.

25 parts of crude petroleum may be used instead of 20 of distilled petroleum. The calorific value of this combustible is said to be 2 to 3 times that of coal. *Les Mondes, Nov.* 6, 1873.

Purification of Coal Gas.—DUFFEE patents the use of dry lime as a purifying agent. This is placed in wicker-work trays of a peculiar description, of which a detailed account is given in the patent specification. Patent No. 96062. *Bulletin de la Soc. Chim. Paris, xx.* 574.

Luting for cracked Gas Retorts.—The following mixture is recommended :—

Powdered glass	5 parts
Chamotte powder	5 „
Powdered borax	1 „

When spread over the fissured surface the mass melts and fills up the crevices. A mixture of graphite, clay, and borax may also be used with advantage. *Paper read before the Meeting of the Prussian Gas Manufacturers.*

Linseed and other Oils.—FORD patents the following mode of treatment :—To give to the oils drying qualities it is desirable to avoid boiling, which always damages the oil; instead, the oil is heated in a jacketed leaden vessel to 82° C. (180 F.); the vessel is provided with an agitator. For every 4·5 litres of oil 120 grammes of the following solution of sub-acetate of lead are added, and well mixed by the agitator :—

Neutral acetate of lead	10 parts
Litharge	7 „
Water	40 „

The whole is allowed to stand several hours at 49° C. (120° F.); the oil is then syphoned off, heated again to 49°, and again agitated with 31 grammes of the same liquor for 1 hour; the whole is then allowed to stand at 38° C. (100° F.), and again syphoned off. The operation may be conducted in the cold, but requires a much longer time. *Bulletin de la Soc. Chim. Paris, xx.* 573.

Prevention of Boiler Incrustation.—GONTIER patents the use of a mixture of the following ingredients for the purpose of preventing incrustations in boilers, or of decomposing them when formed :—

Spanish white	2 parts
Soda crystals	2 „
Farina	3 „
Campeachy wood	1 „
Plumbago	1 „

Bulletin de la Soc. Chim. Paris, xxi. 45.

Plastic Elastic Material for Joints, Valves, &c.—JENKINS patents the use of the following materials for this purpose, the nature varying with the character of the products passing through the conduits :—

	For Steam.		
Caoutchouc	21·25	24	20
Gum lac	16·50	6	4
Silicate of magnesia	26·50	—	—
French chalk	16·00	—	—
Litharge	15·50	—	—
Lampblack	3·25	3	1
Sulphur	1·00	3	2
Mica	——	45	50
Talc	——	10	15
Wood charcoal	——	3	—
Plumbago	——	6	8
	100·00	100	100

For Hot Water.	
Caoutchouc	21·33
Gum lac	11·00
Silicate of magnesia	21·67
French chalk	24·33
Litharge	13·50
Lampblack	2·59
Sulphur	5·58
	100·00
For Oil.	
Caoutchouc	24·16
Gum lac	15·00
Silicate of magnesia	20·17
French chalk	24·17
Litharge	32·17
Lampblack	2·17
Sulphur	2·16
	100·00

Bulletin de la Soc. Chim. Paris, xx. 576.

Dry Collodion Process.—A. CONSTANT recommends the use of old collodion, or of collodion made from gun cotton prepared at a high temperature. It is essential to have a covering which will preserve the porosity of the collodion, and which will not alter on keeping for several months, and yet which can be easily softened so that the exposure may not be too long when the plate is used. *Bulletin de la Soc. Franc. Photographie*, 1873, *No.* 9.

Collodion for Photography.—T. SUTTON states that a collodion which contains much iodide and a considerable amount of bromide acts the most rapidly. The silver nitrate bath should not be stronger than 8 per cent. Pure neutral recrystallized nitrate should be used, a little bicarbonate of sodium being added from time to time, and the whole exposed to the light; after filtration the bath is ready for use. *Bulletin de la Soc. Franc. Photographie*, 1873, *No.* 9.

Heliochromy (Colour Photography).—SAINT FLORENT employs the following solutions :—

No. 1 Silvering Solution.

Silver nitrate	20 parts
Water	20 „
Alcohol	100 „
Nitric acid	10 „

The silver nitrate is dissolved in the water, and then the alcohol and acid added.

No. 2.

Hydrochloric acid	50 parts
Alcohol	50 „
Uranium nitrate	1 „
Zinc white	1-2 „

The zinc white is dissolved in the acid, and the other substances added; the dry silvered paper is then soaked in the solution and exposed to the light until it becomes violet blue; it is then dried, again plunged in the silver solution, and then into liquid No. 2, and so on, till the paper acquires an intense violet blue tint.

No. 3.

Water	100 parts
Acid mercuric nitrate solution	4-5 „

The paper is then soaked in No. 3 for five or ten minutes, and again dried. On exposure under a coloured glass, for thirty or forty seconds, there is then obtained a proof with a white ground, and all the colours of the original.

Greater speed is attained by adding to the last bath the following liquor :—

Saturated solution of potassium dichromate	2 parts
Sulphuric acid	2 „
Potassium chlorate	1 „

The fixing solution is a dilute alcoholic solution of ammonia :—

Ammonia	5 parts
Alcohol	100 „

The paper is washed in this solution and then plunged into a strong solution of an alkaline chloride.

To obtain coloured views with the camera, the action of diffused light must be avoided as far as possible, by fixing to the instrument a pasteboard cone, so as to intercept extraneous rays. *Bulletin de la Soc. Franc. Photographie*, 1873, *No. ix.*

Amount of Phosphoric Acid in Coal.—This constituent of the coal has hitherto received but little attention. The inspector-in-chief of mines in France, Lechartier, and the engineer, Durrand-Claye, have collected all that has been established by analysis on this head. The following figures from their work deserve to be quoted :—

Coal.	Percentage of ashes.	Percentage of phosphoric acid in the ashes.	
From Dowlais	1·20	0·99	
„ „	2·00	0·21	
„ „	3·32	2·00	Stated by Dr. Percy
„ „	7·18	3·01	
„ Pontypool	—— not given	0·75	
„ Ebbwvale	—— not given	0·88	
„ Fife	—— not given	0·88	
French coal in lump	2·90	1·00	Analyzed by Lechartier, and Durrand-Claye
„ „ small (washed)	4·91	0·20	
„ coals, various	5·30	1·35	
„ „ „	6·17	1·12	
„ „ „	13·27	0·74	
„ „ „	9·71	1·50	
„ „ „	5·80	1·28	
Coals from U. S.	5·15	0·13	Report of Geolog. Survey of Ohio, 1870.
„ „ „	7·94	0·41	
„ „ „	3·34	2·23	
„ „ „	2·37	0·29	
„ „ „	7·67	0·51	
Different English coals	—— not given	0·75	Stated by Sir Henry de la Bèche, and Dr. Playfair.
„ „ „	—— not given	0·74	
„ „ „	—— not given	0·63	
„ „ „	—— not given	0·88	
„ „ „	—— not given	0·88	
„ „ „	—— not given	0·18	
„ „ „	—— not given	0·40	

Polytech. Centralbatt. 1873, 783.

Szekely's "Brilliant Photographs."—Under this designation, a specially delicate kind of photographs is described, and their mode of production is the following :—Two negatives of one object (in unchanged position) are prepared in the usual way, *but without intensifying the developed picture;* the two plates are next placed upon one another, so that the lines of the image of the one completely coincide with the lines of the image on the other, and the two plates, when thus arranged, are immovably fixed by sticking paper over their edges. The use of intensifying chemicals is hereby dispensed with, and consequently the image does not require retouching. In making copies from this double plate, it is handled just as a single one. *Photogr. Corres.; through Polytech. Centralblatt.* 1873, 198.

§ 6. *Miscellaneous.*

Gum Arabic.—By adding to mucilage a solution of aluminium sulphate the difficulty is got rid of that the gum only imperfectly adheres to unsized paper, and that it will not bind firmly together paper and cardboard to wood or metals, &c.

The best results are given with the following solutions :—

No. 1.

Gum	2 parts
Water	5 „

No. 2.

Aluminium sulphate	2 parts
Water	20 „

To 250 grammes of this mucilage add 22 of the solution No. 2. *Pharmaceutische Centralblatt. xiv.* 205.

Cement for Metals and Glass.—FRANKE gives the following receipt :—

Fine litharge	2 parts
Dry ceruse	1 „

Triturate to a plastic paste with a mixture of—

Boiled linseed oil	3 parts
Copal	1 „

Polytech. Notizblatt, xxviii. 218.

Portable Ink.—BOETTGER impregnates sheets of paper with aniline black, and then compresses the whole into a compact block ; when ink is required a fragment is cut off and steeped in water. *Bulletin de la Soc. d'Encouragement*, 1873, *November.*

Reproduction of Designs in Metal, Glass, Marble, &c.—COL patents the following process :—The surface to be etched is covered with a varnish, on which the pattern is then traced ; the whole is then placed under water, and the varnish removed from the tracings ; the etching is effected by an acid. No details are given as to the nature of the ink or varnish used. *Bulletin de la Soc. Chim. Paris, xxi.* 48.

Reproduction of Drawings, Writings, &c.—ZUCCATO patents the following process :—Characters or designs are traced with a caustic ink (potash or soda) on a leaf of paper varnished on one side ; when the ink is dry the other face is also varnished. The caustic destroys the varnish, so that on washing the paper the characters appear. The paper is then placed on one or more sheets of paper impregnated with ferric chloride solution, thickened with gum ; and on the other side are placed sheets of paper similarly moistened with potassium ferrocyanide, or gallic acid ; the whole is then pressed, when the characters are reproduced on the second sheet. *Bulletin de la Soc. Chim. Paris, xxi.* 45.

The Cardiograph.—CYON suggests that this instrument is capable of use for purposes other than physiological and pathological investigations ; for example, round the bed of a dying man are some whose hearts beat strongly and slowly through pure sadness ; others whose impatience for the dead man's shoes causes their hearts to beat quickly and feebly. Improved cardiographs might reveal the true sentiments of the spectators, and might yield information of importance in relation to the will of the moribund ; or the indications of the instrument might enable one to determine which of the lovers of a young girl are actuated by pure affection, and which have only a love proceeding from the mouth. The examination of the traces of the instrument might thus preserve the fair sex from dangerous seductions ; or, again, the nature of the curves might afford evidence of the guilt or innocence of a prisoner on his trial. *Revue Scientifique*, 1873, *No. xxi. p.* 487.

[A pocket instrument for the above desirable purposes might prove extremely useful, and would be a charming present for both old and young.]

Instrument for measuring the height and relative proportions of the Human Frame.—BONOMI has invented an instrument for this purpose, by the use of which he found that out of eighty-four people fifty-four had long arms, twenty-four short ones, and only six arms of the same length as the body ; of all these there were not two of the same height who had arms of the same length. *Revue Scientifique*, 1875, *p.* 523.

Dynamite.—ANTHOINE and GENOUD patent the application of unsized paper and other spongy organic matters to the manufacture of dynamite in lieu of silica. The paper, &c., may be impregnated with successive coats of nitrate of potash, picrate of potash, or chlorate of potash, before saturation with nitro-glycerine. *Bulletin de la Soc. Chim. Paris, xx.* 480.

Lithofracteur.—GUSGEN and DUBOIS patent the following process :—A mixture is made of spirit (of wine?), of nitrate of manganese, and of wood shavings, impregnated with a solution of resin in bicarbonate of soda ; whilst the mixture is moist infusorial earth is added. The resulting mass is sprinkled with bisulphide of carbon ; bone or wood charcoal is then added, and finally the whole impregnated with nitro-glycerine. The mixture, containing 45 to 55 per cent. of nitro-glycerine, is then made up into cartridges. *Bulletin de la Soc. Chim. Paris, xx.* 374.

Ouachita Whetstone.—C. E. WAIT gives the following analysis of a snow-white specimen of this valuable mineral :—

Sp. gr. 2·649.

Silica	99·635
Alumina	0·113
Magnesia	0·087
Sodium oxide	0·165
Potassium oxide	trace
Iron	trace
	100·000

Sodium hydrate dissolves but little of the silica (1·65 per cent. after three minutes' boiling with a 20 per cent. solution, 3·56 after half an hour), whence it appears that the silica is not in the opaline condition, but in a state more approximating to quartz. *Chemical News, xxviii.* 272.

Plastic Charcoal for Filters. — KLETZINSKY uses either of the following mixtures :—

Coke	60 parts
Animal charcoal	20 „
Wood charcoal	10 „
Pipe clay	10 „
	100

Or,—

Coke	10 parts
Animal charcoal	30 „
Wood charcoal	20 „
Asbestos in short fibres	40 „
	100

The ingredients are pulverized (asbestos excepted) and mixed up to a paste with treacle, and moulded into the required shape, or into blocks or plates ; the masses are gently dried, heated in a muffle, and cooled slowly ; they are then treated with weak hydrochloric acid to remove soluble earthy matter, again washed and dried, and heated to redness in a well closed muffle. *Dingler's Polytech. Journal, ccix.* 396.

Gelatinous Silica.—MAUSSIER patents the use of this material for the manufacture of refractory bricks, cements, &c., for purifying the scoriæ of forges, and for lining the beds of furnaces for chemical or metallurgical operations ; he extracts it from rocks, fragments of glass, slags of puddling furnaces, &c., employing fluor spar and sulphuric acid conjointly so as to form hydrofluoric acid which attacks the silicate. *Bulletin de la Soc. Chim. Paris, xx.* 477.

Staffordshire Glazing.—SEGER being desirous of imitating the beautiful glazing which distinguishes the pottery of Staffordshire, submitted a carefully selected specimen to analysis, and found it to contain :—

Silica	40·56
Alumina	6·07
Lead oxide	40·04
Iron oxide	2·59
Manganese suboxide	7·14
Lime	2·58
Alkalies and loss	1·02
	100·00

In order to produce a Staffordshire glazing, it would be necessary to employ the following materials and proportions :—

Quartz	28 parts
Lead oxide	40 „
Pipe clay	18 „
Manganese (best)	9 „
Chalk	5 „

Polytech. Centralblatt. 1873, 595.

The Glass-cutter.—This ingenious instrument is intended to supersede the diamond for the purposes of glass cutting, and consists of a tiny steel wheel of the diameter of $\frac{1}{10}$th of an inch or even less. Of course, its edges are very

sharp. It is passed with pressure over the glass plate, and produces a faultless cut. Trials made by the discoverer, Herr LEGRADY, in various German and Austrian glass-works, have shown that it divides a plate of 1¼ inch thickness with great facility, and much cleaner than the diamond. Thin glass plates, however, cannot be managed so easily, since considerable pressure is required in the use of the instrument. *Polytech. Centralblatt.* 1873, 202.

Apparatus for Cooling Liquids.—A new arrangement is proposed whereby with the aid of ether, or other suitable volatile liquid, the cooling and refrigerating of water and other liquids may be economically effected. The refrigerator consists of a horizontal rotatory drum, mounted in a fixed cylindrical water-tight case, and fitted with a core or filling block, which leaves but a narrow space between it and the sides of the drum. Above this case is mounted a condenser, consisting of a vessel fitted with a serpentine pipe and with horizontal partitions, which are interposed between the bends of the pipe. This condenser is supplied at bottom with water, which flows upwards over the whole length of the pipe, and serves to cool its surface. If desired the pipe may be fitted with an internal tube through which cold water may be run to increase the cooling surface of the condenser. Ether or other volatile liquid is supplied to this pipe, and thence descends in a continuous stream to the drum of the liquid-refrigerator, which drum by its rotation causes the ether to spread over its inner surface. The periphery of this drum is formed of flanged rings, which are bolted together to make up the required length, and the inner periphery of these rings is grooved in order to increase the area of the surface exposed to the ether. One of the trunnions of this drum is made hollow to allow of the introduction of the ether into the drum, through this opening the vaporized ether is also drawn off; the drum rotates in water or brine, which is supplied to the bottom of the case, and the discharge of the cold water or brine therefrom in a state for refrigerating takes place at the upper part of the case. The vapour passes off to a refrigerator, constructed like the ether condenser already described. The worm pipe of this refrigerator is connected with a vacuum pump which draws the ether vapour from the rotating drum, and through the serpentine pipe (where it is cooled), and passes it forward to the serpentine pipe of the ether condenser. The overflow water from this condenser may discharge into a cistern below, and this condensing water may be returned by a circulating pump to the condenser. In like manner the overflow water from the vapour refrigerator may be received into a cistern and again supplied to the refrigerator by a circulating pump. These several pumps are all worked by the engine employed to give motion to the drum of the refrigerator.

Magic Images.—The property some metallic salts possess of changing their colour on exposure to higher temperatures, and of regaining the original colour on return of the normal temperature, is now largely utilized for the preparation of so-called magic images. The salts mostly employed are those of cobalt (cobaltic chloride), and some double salts of mercuric iodide. The pink colour of cobalt chloride becomes blueish-green on heating, from loss of water: on cooling, the pink tint re-appears owing to absorption of moisture from the atmosphere. If a very dilute solution of this cobalt salt is used for writing, the written characters are quite invisible until the paper is warmed, when they will appear of a blueish colour. This peculiarity of cobalt chloride has long time since led to its application in secret writing.

In preparing pictures the cobalt salts and the mercuric iodides may be employed along with ordinary water-colours. A favourite pattern is a winter landscape, which on being warmed turns into a rich summer scene—the white sky becomes blue, the snow-covered soil and the bare trees appear of a luxuriant green. To produce the green of these latter objects some nickel is added to the cobalt chloride; to obtain a full red for berries, &c., a weak solution of nitrate of cobalt is used; and to call forth a deep blue for flowers, pure acetate of cobalt is recommended.

But all the cobaltic colours are rather pale. They are surpassed in intensity and effect by the scarlet mixture of mercuric iodide with cupric subiodides, which turns black at higher temperatures, and by the yellow mixture of the iodides of mercury and silver, which assume a rich orange colour.

It is proposed to use these colours for painting designs on lamp screens and similar objects which are exposed to higher temperatures in the course of their application.

The preparation of the above-mentioned cobalt salts is known; they can, moreover, be got from any druggist, but the mercury double salts must be prepared by the person who wishes to employ them. The following prescription may prove useful. An aqueous solution of potassic iodide is added, in drops, and with constant shaking of the mixing vessel, to a similar solution of corrosive sublimate until no further precipitate appears. The mother liquor is poured off, and the precipitate washed and subsequently dissolved in potassic iodide. On adding silver nitrate to this solution a yellow precipitate of mercury-silver iodide—is obtained; on adding cuprous chloride to it a red precipitate of cuprous iodide with mercury iodide is produced. Both colours are fixed on paper by means of gum-water. *Polytech. Centralblatt*, 1873, 134.

[*Note by Abstractor.*—The beauty and surprising effect of the copper-mercury combination can be confirmed from the writer's own experience: pictures thus prepared were exhibited at the British Association meeting at Norwich (1868), where the first notice on this interesting mixture was brought forward by Meusel, its discoverer. The rich red assumes a fine purple hue before becoming dark (not absolutely black).—R. G.]

ABOUT CIGARS.

THE "New York Times" says:—"There is more money spent every day in New York for cigars than for bread. Now, while there is nothing better, in the way of something to smoke, than a first-class Havannah cigar, there is nothing nastier than some of the cheap abominations made in that shape, as everyone knows who has had to ride from Harlem to New York in a late smoking car with half-a-dozen roughs. . . . There is a great deal more in the choice of a cigar on account of its outside appearance than one not accustomed to it would suppose. A wrapper which has that which the Cubans call *calidad* makes the cigar much stronger than one which does not possess it; that is to say, that the wrapper which has *calidad* contains more essential oil than one which has none. The presence of the essential oil is denoted by an abundance of small pustules on the surface of the leaf, and by a general rich, oily appearance. The value of cigars does not increase in direct ratio with their size; for, owing to the difficulty in getting good wrappers for the larger kinds, the expense of their manufacture is much increased. Upon one occasion, in Havannah, a manufacturer received an order for a thousand cigars intended for a present for the Queen of Spain's husband, Don Francisco de Asis, which he agreed to make for 1,000 dollars. They were delivered in due time, and, packed in a richly mounted cedar chest, were sent to the royal recipient. They were magnificent cigars, of the *cazadores* (huntsmen), or longest size, all of the same colour, and so smoothly made as to look as if they had been turned out of hard wood, instead of made of rolled tobacco. They were placed on exhibition for a few days before they were sent to Spain, and a gentleman who saw them, wishing to make a present to some dignitary, asked the manufacturer to make him a like number at the same price. To his surprise, the order was refused. The manufacturer said he could not do it for the money. His explanation was that it was not the actual cost of the tobacco and the labour of making them, but it was on account of the trouble and expense met with in selecting the wrappers. He said he had to pick over thousands of bales before he could secure a sufficient number of the proper length, colour, and fineness. Some two years ago there was a story of a Cuban cigar dealer in Broadway, who selected cigars for his more favoured customers by ear. It was said that he put the cigar to his ear and listened intently for a moment, and by the cracking of the tobacco was enabled to judge of its quality. This was a good advertising dodge, but in practice it was all nonsense. None but that wily Cuban ever heard of such a mode of trying a cigar. In the island of Cuba that which we call a cigar is called a *tabaco* (a tobacco), and when it is required to discriminate between the manufactured and the unmanufactured article it is called *tabaco torcido*, or rolled tobacco. This, however, is only necessary when used in the plural. In Mexico a cigar is called a *puro*, and in Peru and some of the other Spanish American countries it is called a *cigarro puro*, in contradistinction to the *cigarro de papel*, or cigarette. Cigarettes in Cuba are called *cigarros*, and their consumption is enormous. Strange as it may appear, there are some confirmed smokers in Cuba who never use cigars at all, but confine themselves to cigarettes. To the New-Yorker it looks curious to see a great bearded man smoking a tiny cigarette; and, indeed, were he to smoke his cigarette as the New-Yorker would smoke his cigar, it would be labour lost, so far as getting any effect of the tobacco was concerned. But the cigarette smoker inhales the greater part of the smoke—it goes directly into his lungs and into contact with a large surface of mucous membrane, and, indeed, with the blood itself. Were the New

York cigar smoker to smoke a cigarette in the same way it would make him so giddy that he would be compelled to give it up long before it was consumed. That the smoke does go into the lungs is proved by the fact that a cigarette smoker can inhale the smoke and exhale it again after drinking a glass of water. The wholesale prices of domestic and imported cigars in New York are about as follows per thousand :—Domestic, all American tobacco, from $8 to $40 ; domestic, part American and part imported tobacco, $35 to $75 ; domestic, all imported tobacco, $50 to $140 ; imported, from $45 to $270. This is not a fair quotation, however, for the only cigars sold at $45 are the Damas, which are very small. An imported cigar of the average size costs from about $140 to $175. The imported cigarettes are sold at about $156 per thousand packages. A few Manilla cigars and cheroots are sold in New York ; their price at wholesale is from $55 to $75. Connecticut, Ohio, Pennsylvania, Missouri, and Wisconsin furnish the tobacco used by the cigar-makers in the United States—the first named the best, and the last the poorest. The following statement, clipped from a contemporary, is given for what it is worth :—'The present annual production of tobacco on the globe has been estimated by an eminent English writer at 4,000,000,000 pounds. Suppose it all made into cigars, 100 to the pound, it would produce 400,000,000,000. Allowing this tobacco, unmanufactured, to cost, on the average, 10 cents a pound, we have $400,000,000 expended every year in its production. At least one and a-half times as much more is required to manufacture it into a marketable form, and dispose of it to the consumer. If this be so, then the human family expend every year $1,000,000,000 for one of its so-called petty vices.'"

HYDRAULIC MACHINE TOOLS.

Ralph H. Tweddell's System.

WE have long been of opinion that hydraulic machinery is destined to occupy a far more important position in our manufacturing establishments than it has hitherto done ; not but that its advance has already been rapid, but because we conceive that the idea which certainly at one time prevailed, that it was only suited to the slow moving of heavy weights, such as dock gates, &c., is disappearing, and people are beginning to understand how almost universally applicable it is as a motive power to nearly every sort of machinery. In our last number we illustrated and described some fixed and portable riveting machines, a subject to which we propose to return in an early impression, by Mr. Ralph H. Tweddell, C. E., Westminster, and we now give an illustration of a hydraulic chain-cable shears by the same gentleman. Our readers are probably aware that there is an Act of Parliament relating to the sale of chain-cables and anchors, which requires that the tester of the chains shall "cut out a piece of three links from every fifteen fathoms, and shall test that piece by subjecting it to the appropriate breaking strain." And one of the objects contemplated by Mr. Tweddell in designing these shears was their use for so cutting out the testing links. We take it that this machine has many advantages, especially for the immediate purpose for which it is intended, over other methods, such as the ordinary geared machines driven by belting steam hammers or circular saws, inasmuch as there is nothing carried away by the momentum of the fly-wheel, and that its movements are perfectly noiseless and clean.

The machine we illustrate is a double one, as will be seen from a glance at the drawing, and is so adapted that the knives under the larger cylinder will shear from 2¼ to 1½ in. cables, and those under the smaller one from 1½ in. downwards, an arrangement which saves a good deal in avoiding constant changes of knives. It is worked from an accumulator loaded to a pressure of about 2,000 lbs. per square inch, but force pumps might be applied instead ; indeed, we believe that the preliminary trials of the machine were made with these latter ; the accumulator is in our opinion, however, by far the preferable method, and we may here name that several of these tools have been and are being used at public chain tests on the Tyne, Wear, and at Chester.

Since, however, the machine we illustrate was designed, Mr. Tweddell has applied similar arrangements to ordinary boiler yard punches and shears, with the effect of proving the fallacy of the too generally accepted opinion that all hydraulic work is necessarily slow, for some of these punches and shears have run up to twenty-five strokes a minute, which is certainly equal to the highest speed of the geared machines.

A very perfect plant on the hydraulic system is, we understand, now on the point of completion, for the firm of F. Marten and Co., Limited, Liverpool, at whose works Mr. E. Cowling Welch, the company's engineer, has had erected a large set of pumps, accumulator, corrugating presses for roof-work, punches and shears for 1-inch plates, and also a portable riveter ; the pressure to be used is 1,500 lbs. per square inch, but it has been run up to 2,000 lbs. and in some instances to 2,300 lbs. per square inch.

The great question at issue is, as was very forcibly urged by Mr. Tweddell before the Institute of Mechanical Engineers some months past, the relative economy of the means of transmitting power ; and believing, as we do, in the future success of the hydraulic system, we are glad to see that Mr. Welch has given the inventor so fair a field for the development of his plans, the results of which we shall not fail to give to our readers.

Referring also for a moment to our article on "Riveting," in the number for December, 1873, we think that perhaps a better arrangement would have been to have divided the subject as follows :—

1st. Machine riveting with levers or cams.
2nd. Steam riveting as directly or indirectly applied.
3rd. Hydraulic riveting.

And with reference to the remarks made as to Mr. McFarlane Gray's machine, they only, of course, apply to the comparative merits of steam, air, or hydraulic power for portable or movable machines, and not to the three classes above named, which are only *fixed* modes of riveting. Supplementing further our article, we may say that the earliest machine riveting was of the first class, and was the invention of Fairbairn; the second was used by Yarforth and Cook ; and the third is Tweddell's, of the advantages of which we have given our opinion. The only *portable* machines which have ever been started are McFarlane Gray's and Tweddell's, and the essential difference between them is that the former has a percussive action, and is worked by air or steam, whilst the latter exerts a steady pressure, and is worked by water ; and steam is here open to the serious objection that everything gets red hot, whilst with water power, on the contrary, every thing is kept cool.

ON SOME RECENT IMPROVEMENTS IN THE MANUFACTURE OF ARTIFICIAL STONE, AND THE APPLICATION OF SUCH STONE TO CONSTRUCTION AND OTHER PURPOSES.

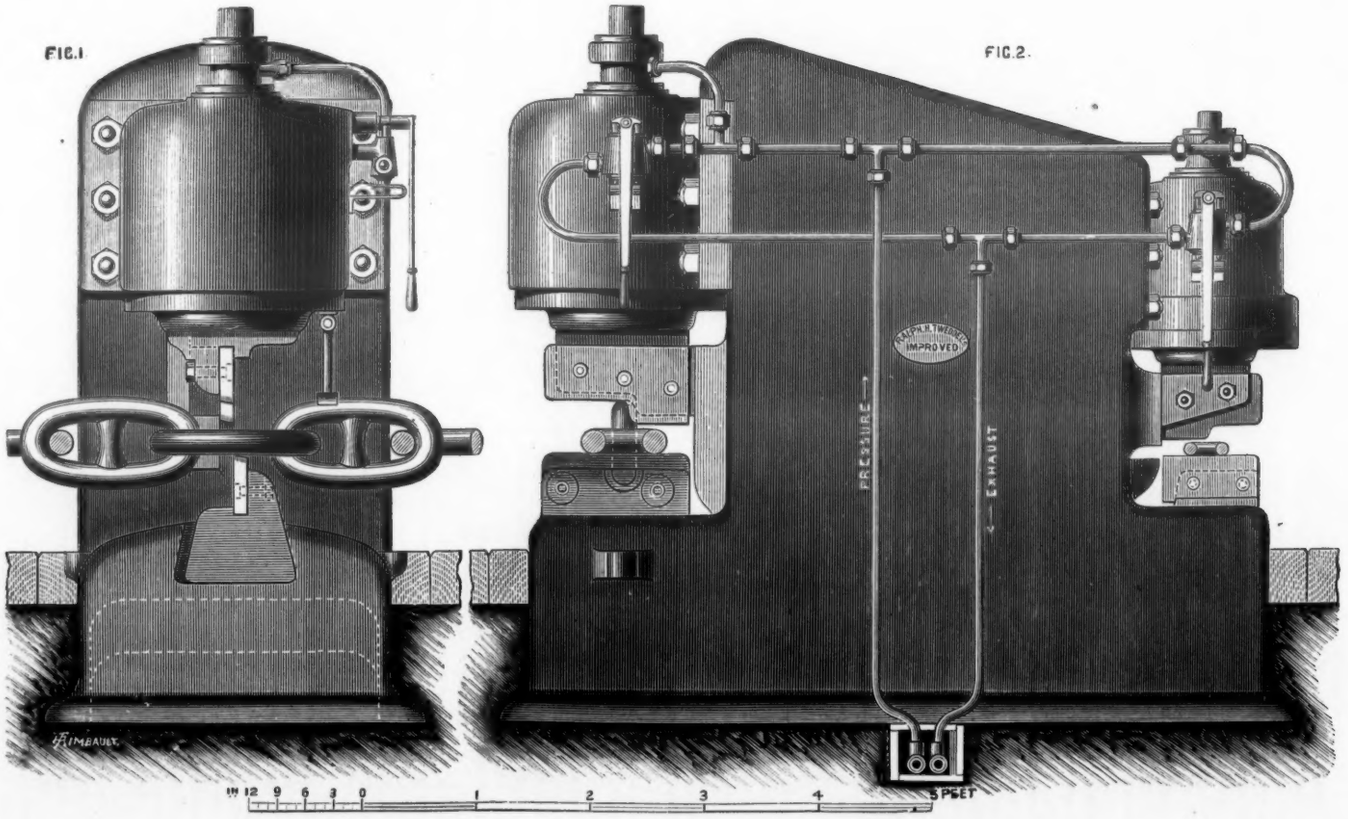
By Frederick Ransome, C.E.

(A Paper read before the Franklin Institute, November 10, 1873.)

BEING on a visit to America with a view to the introduction of a process for the manufacture of stone, which has been successfully employed in England and in other parts of the world, the author was kindly invited to read a short paper upon the subject at the Institute.

It may be desirable at the outset to state that it is not the object of this paper to treat of the many various methods for making artificial stone which have from time to time been brought before the public ; their name is legion, and their several natures and properties have already been dealt with by abler and perhaps more disinterested investigators. Therefore, whilst recognizing peculiar merit in many of such methods, and appreciating advantages they have severally afforded in the arts both of construction and ornament, when properly applied, the author will allude more particularly to those in which he is more directly interested, to the perfection of which he has devoted the greater portion of his life, and which he believes are, in most respects, essentially different, both in the details of their manufacture, and in many of the various purposes for which they are especially designed.

The progressive development of the natural world, through periods which occurred long before the dawn of the most remote traditions of antiquity, have placed at the disposal of man materials which for the most part eminently subserve the various purposes of construction and decoration. These materials, however, such as the granites, marbles, sandstones, limestones, so occur in isolated groups, in some instances so remote from the



HYDRAULIC MACHINE TOOLS. (RALPH H. TWEDDELL'S SYSTEM.)

centres of civilization, the cost of labour in working into form, and the consequent waste of the material itself are so great, as to render them prohibitable for general use, except in local situations.

The requirements of men soon demanded a material which should approximately fulfil the conditions of stone in the construction of their buildings, and this necessity was in the earlier ages supplied to a great extent by the manufacture of bricks, concrete, &c.

The advantages afforded by these substances were readily recognized by the ancients, and have been fully appreciated in modern times; but great as these advantages are in a constructive point of view, they fall very far short of the requirements of the present age.

It is therefore no matter for surprise that numerous attempts have been made from time to time to supersede or supplement the productions of nature by the imitations of art, and the importance of producing a material combining all the merits, without having the defects, of the most useful building stones, and at the same time possessing advantages peculiarly and specifically its own, was long since recognized by the author, and he adopted the task of solving the problem of manufacturing a stone which should economically answer at least some of the varied purposes of the products of nature.

He commenced his investigations into the nature and properties of stone just thirty years since, and he found that, with comparatively few exceptions, the hardest and most durable were those in which silica abounded, either in the form of quartz or crystals, or in combination with lime or other substances. With this fact in view, he commenced a series of experiments, and selecting silicious sand (composed of crystals of nearly pure quartz, and which may be obtained in abundance in almost all parts of the world) as a base, he proceeded to combine the particles by the admixture of a small proportion of powdered glass and clay under hydraulic pressure, and subsequently more completely uniting the mass by partial fusion. After numerous unsuccessful attempts, and after having, as he believed, exhausted the various combinations of sand, &c., with almost every known cement within his reach, it occurred to the author to substitute a concentrated solution of silicate of soda or potash for the other cementing materials he had previously employed. Sand, when mixed with this solution of silicate of soda or potash, and pressed into a mould, formed, when dried, a very hard stone, having a close and uniform texture, but which, however, became disintegrated upon being exposed to moisture. The next step was to submit the compound to the action of heat, when the free alkali of the cementing silicate, combining with an additional quantity of the silex of sand, produced an insoluble silicate unaffected by moisture. The author obtained his first English patent for this process in 1844, and immediately established works for the manufacture of what was then known in the market as the "patent silicious stone." Such were in general the results obtained, and such, with various modifications in points of detail, was the process adopted by the author in manufacturing stone for many years.

The stone thus prepared was found to be very hard, of beautiful texture, and perfectly indestructible by atmospheric influences or acid vapours. Many illustrations confirmatory of this statement may be seen at the present time, where the "patent silicious stone" has been exposed to the most vitiated atmosphere in London, the finest edges and tool marks upon which are still as sharp as when they first left the manufactory. There were, however, serious practical objections to this mode of manufacturing, which will at once occur to the minds of many present—the operation was at once both tedious and expensive. Special care and considerable time had to be taken to drive off all superfluous moisture before the articles were placed in the kiln, in which the heat had to be generated and reduced very gradually; the risk of flaws and of cracking formed a very serious item in the process, and after all the care and expense which could be expended to prevent the failures alluded to, it was found to be practically impossible to secure truth of outline, or, in other words, to prevent distortion by the expansion and contraction produced in the process of burning. The next problem was to determine how to convert the soluble silicate of soda into some insoluble silicate, which should possess the properties requisite for the formation of a good, hard, compact and durable stone without the action of fire heat, which had been found so inconvenient and expensive in the former methods.

In the year 1856 the author secured letters patent in England for a means of rendering stone, bricks and other building materials less liable to decay by first saturating these with a solution of silicate of soda, and afterwards applying a solution of chloride of calcium, which immediately decomposed the former, and produced an insoluble silicate of lime in the stone, &c., so operated upon; and in the year 1861, in consequence of the premature decay of the stone of the new Houses of Parliament at Westminster, a special committee was appointed by Government to examine and report on the causes of such decay and the best means of preserving the stone from further injury. The author, in common with others, was summoned to attend and give evidence on the subject; and after stating the satisfactory effects produced upon the stone of some of the buildings upon which he had operated, he proposed that, in order to demonstrate more conclusively the efficiency of the process, that a piece of the stone should be reduced to powder, and then, by the aid of the two solutions of silicate of soda and chloride of calcium, to reconvert the powder back into a solid stone.

The experiment was tried, and the result was so completely successful that the author immediately applied for a patent for the manufacture of stone by the employment of the above and similar ingredients, which patent was accordingly sealed in England on the 3rd of October, 1861. Arrangements were at once made for the manufacture of stone upon a large scale by this process, which, in order to distinguish it from the "patent silicious stone" already described, is called the "Ransome patent stone." This material, in which sand and silicate of soda, &c., after being thoroughly incorporated in a suitable mixing mill and moulding into the form required, is saturated with a concentrated solution of chloride of calcium, by exhausting the air by means of air pumps, or by forcing the solution through the moulded mass by gravitation or otherwise. Double decomposition of the two solutions immediately takes place, resulting in the production of an insoluble silicate of lime, firmly uniting and enveloping all the particles of which the mass is composed, and a solution of chloride of sodium or common salt, which is subsequently removed by the free application of water. This description of stone has now been extensively used in England during the past twelve years, and the demand for it is very rapidly increasing for all kinds of building details, especially for those of an ornamental or artistic character. It is perfectly free from all liability to distortion or shrinkage, is unaffected by any variations of climate or temperature, and is uniform and homogeneous in its texture. It has been most successfully employed in various countries abroad, especially in India, where the Government has established works for its manufacture. It has also been employed to a considerable extent in this country, especially in Chicago and San Francisco, where it is successfully manufactured. There are upon the table several specimens of this stone which were manufactured at the works of Messrs. Wright and May at Chicago, and which bear a very favourable comparison in appearance with the best descriptions of the natural stones of this country. Its cost is less than half that of natural stone in details of an ornamental character, especially where there is much repetition, and its enduring quality is now so fully established as to need no comment.

When the author visited Chicago a few weeks since, he inspected several buildings which have been erected since the calamitous fire of 1871, faced entirely with the Ransome stone, manufactured by Messrs. Wright and May, which may easily be mistaken, by a casual inspection, for the marble of the district, and he was informed upon reliable authority that there were about 200 buildings in the city in which the "Ransome stone" had been employed for dressings or finishings, and although the thermometer was as low as 27° below zero during last winter, it stood perfectly uninjured.

Dr. Ed. Frankland, in writing upon the Ransome stone, says: "I am induced to believe that Mr. Ransome has invented a material which, with the exception of the primary rocks, is better capable of giving permanency to external architectural decorations than any stone hitherto used."

Dr. A. Snowden Piggot, analytical chemist, Baltimore, says: "Double decomposition ensues, and a silicate of lime of a glassy hardness and imperviousness coats every grain and binds the whole into one solid mass. Such a stone carefully made may be considered proof against all ordinary atmospheric influences."

Professor Ansted states: "A parallel bar of Ransome's stone, 4″ × 4″, resting on iron frames so as to bear one inch at each end, with 16 inches clear between the supports, sustains a weight suspended from the centre of 2,122 lbs. A 4-inch cube of Ransome's stone sustained a weight of 30 tons before it was crushed."

One more special application in which the Ransome stone has proved eminently successful may suffice, viz. in the manufacture of grindstones, which surpass in their cutting properties all those of the natural stone in comparison of which they have been tested.

With a view fairly to test the comparative grinding power of

these stones, Messrs. Donkin and Co. constructed a simple apparatus by means of which an equal and uniform pressure could be exerted upon pieces of steel presented to the faces of the several grindstones. The pieces of steel were cut off the same bar, and were accurately weighed before the operation; the grindstones were then set in motion. The Newcastle stone ground away a quarter of an ounce of steel in 11 hours. The "Ransome stone" ground away a quarter of an ounce of steel in 16 minutes. The same description of stones are now largely used in England for shelling and cleaning rice, and for grinding and rubbing purposes generally, and are exported to all parts of the world.

The foregoing is a brief history of the material manufactured by the author down to 1870, at which time he developed another process as distinct from the last described as was that from the one patented by him in England in 1844, and for which he obtained another patent in England in October, 1870, and a subsequent patent in the United States in 1872. This latter process, for the sake of distinction, is called "Ransome's Apœnite."

It was found in practice that the process of washing the "Ransome stone" so as completely to remove all trace of the chloride of sodium from large masses was open to objection; it was both tedious and expensive, especially in localities where there was a difficulty in obtaining a good supply of tolerably pure water at a reasonable cost; besides which, in producing so large an amount of chloride of sodium, which had to be afterwards removed from the stone as a waste product at considerable cost, the bulk of the alkali, which was by far the most expensive ingredient in its composition, was ejected instead of being utilized, for still further increasing the density, strength, and hardness of the stone.

This defect had for a considerable time engaged the attention of the author with the view of effecting a remedy, and step by step it has been accomplished by a process so simple, and in a manner so satisfactory in its results, as to leave little or nothing to be desired.

Some years since a silicious deposit was discovered at the base of the chalk hills in Surrey, possessing some very peculiar properties, amongst others, that of being readily soluble in a solution of caustic soda or potassa, at a moderately low temperature.

Taking advantage of this peculiarity, the author commenced a series of experiments, in order to determine if it were not possible, without the use of chloride of calcium, to produce a stone in all respects equal in quality to what had hitherto been made, and in this he has now succeeded, by mixing, in lieu of the chloride of calcium, suitable quantities of lime (or substances containing lime) and the natural soluble silica above alluded to, with sand and a solution of silicate of soda or potassa, which, when intimately incorporated, are moulded as heretofore, and allowed to harden gradually as silicate of lime is formed by the decomposition of the alkaline silicate produced by the action of the lime. The mass gradually becomes thoroughly indurated, and in a very short time is converted into a very compact stone, capable of sustaining extraordinary pressure, and increasing in strength and hardness with age.

The chemical actions which produce these results appear to be as below stated. When the before-named materials are mixed together, the alkaline silicate is immediately decomposed, the silicic acid combining with a portion of the lime present, forming a silicate of lime, whilst a portion of the alkali in a caustic condition is set free; this free alkali immediately seizes upon the natural soluble silica which constitutes one of the ingredients, and thus forms a fresh supply of silicate of soda, or potash, as the case may be, which is in its turn also decomposed by a fresh quantity of lime: and so on.

If each successive decomposition of the alkaline silicate resulted in setting free the whole of the alkali, these decomposing processes would continue so long as there remained any soluble silica present with which the alkali could combine, or until there ceased to be any free lime to decompose the silicate of soda or potash when produced; the termination of the action being marked by the presence in the stone of the excess of caustic alkali on the one hand, or of alkaline silicate on the other. In reality, however, the whole of the alkali does not appear to be set free as the soluble silicate is decomposed by the lime, there appearing to be formed a compound silicate of lime and soda (or potash), whereby a portion of the alkali becomes permanently fixed at each decomposition. The result of these several changes is that the whole of the alkali is gradually fixed, and none remains to be removed by any subsequent washing or other process.

The tenacious and enduring properties of silicate of lime are too well known to need any elaborate explanation in this paper. It is the substance which has conferred upon the old Roman mortars and concretes the enormous hardness they are found to possess even after a lapse of 2,000 years and upwards.

Upon close examination of a piece of the old Roman concrete, we find that the hardest part of such concrete is not the lime with which it was combined, nor even the flint stones combined therewith, but the hard shelly film which has formed over the external surfaces of the stones, caused by the action of the lime with which they were in contact, and which is silicate of lime.

From the foregoing remarks it will be apparent that, in order to produce the most satisfactory results in the manufacture of artificial stone of the character of that now under consideration, special attention should be paid to the selection of suitable materials, and great care should also be observed in details of manipulation. The sand employed should be clean, sharp, and silicious, free from argillaceous or cretaceous matter. The natural soluble silica exists, in large deposits, in various parts of the United States, and can be supplied in considerable quantities for manufacturing purposes, at a comparatively low price; but it must be borne in mind that these natural soluble silica deposits vary very considerably in the amount of their solubility; and, for the purpose of making the "apœnite" stone, that which is most soluble in a given solution of caustic soda at a given temperature should be selected. Through the kindness of Dr. T. Sterry Hunt, of Boston, the author has received a sample of silicious earth, upwards of 90 per cent. of which is readily soluble, whereas several other samples from other localities have not furnished more than 40 per cent. under the same conditions.

The silicate of soda also requires to be prepared with due regard to the proportions of silica and soda respectively, that containing 66 per cent. of silicic acid with 34 per cent. of soda being found in practice to produce the best general results. A sample of silicate of soda furnished by Dr. Feuchtwanger, of New York, is now on the table, and appears to meet such conditions.

Very much also depends upon the selection of the lime to be employed; and perhaps there are few articles of every-day consumption sold under the same name that differ more widely in their compositions and properties than limes and cements. These substances have been most thoroughly investigated, and the results published by General Gilmore in his very useful "Practical Treatise on Limes, Hydraulic Cements and Mortars," and need only be alluded to in the present paper for the purpose of drawing attention to that which appears to be most suitable for the operations herein described. Amongst these may be selected that known as the hydraulic lime of Teil, and which derives its hydraulic energy from the large percentage of silicate of lime in its composition, viz. 66 per cent. It is slow in setting, thus affording time for proper manipulation in the process of stone-making, and attains high tensible strength, with great power to resist a crushing force. Its hydraulic properties have been largely tested in the construction of the marine works at Marseilles, Alexandria, and other seaports, as also in the great breakwater at the entrance to the Suez Canal and in the Mont Cenis Tunnel. Samples of this lime have been furnished to the author by Messrs. Champin and Gillet, of New York, who are the sole agents of the manufacturers for the supply of this lime in North America; there is also on the table a small fragment of concrete taken from the harbour works at Marseilles after having been submerged twenty-three years.

Well-burnt Portland cement, of good quality, may also be advantageously employed, instead of lime of Teil, where no immediate setting of the mass is required; but so many manufacturers of the so-called Portland cement have of late years sprung into existence in consequence of the increased demand for this article, and so much competition has been excited for the production of an hydraulic cement under this name at a low price, that more than ordinary care should be observed in its selection. The best Portland cement is composed of a mixture of white chalk and an alluvial deposit of rivers in a state of minute division, which substances, after being intimately incorporated mechanically, are burnt in a kiln to a point almost approaching vitrifaction, and afterwards ground and sifted, by which means a compound silicate of lime and alumina is formed, possessing the high hydraulic properties for which the Portland is so famed; but unless these ingredients be so mixed and burnt as to be chemically combined, instead of being merely mechanically incorporated, the so-called Portland cement may be worse than useless, and the employment of such material may lead to very disastrous results.

As comparatively few of the many persons who employ this material have any sufficient opportunity of personally ascertaining its essential properties, it is safer to rely upon the productions of such makers whose experience in the manufacture and whose recognized standing in the commercial world form a sufficient guarantee for a genuine article.

Unquestionably there are such manufacturers upon the value of whose productions every reliance may be placed, amongst

whom, with many others, may be mentioned the names of Messrs. Vicat and Co., and Messrs. Lafarge, in France; and Messrs. White Brothers, the Burham Cement Co., and others in England, who have justly acquired a world-wide reputation. There may also possibly be makers of Portland cement of good quality in this country, but the author's experience has been far too limited to enable him to speak practically as to them.

Having explained the manufacture and chemical composition of the several descriptions of artificial stone herein alluded to, it will be as well in the next place to point out some of the varied purposes for which the "apœnite" process is more especially applicable. The primary condition of materials for construction are, unquestionably, strength and durability, those of a secondary nature being appearance, facility of application to the intended purpose, and economy in use. As regards strength, it has before been stated that the strength of the stone manufactured by the "apœnite" process increased with age. By some experiments which were made for the purpose of testing their possession of this quality, numerous samples were proved, within a month of their manufacture, to be superior to Portland stone. At the age of ten weeks the strength of "apœnite," as compared with Portland stone, was found to be as 7,145 lbs. to 2,630 lbs. per square inch, and as compared with Bramley Fall, 7,145 lbs. to 5,120 lbs. per square inch. As regards durability, the well-known properties of the materials employed in its manufacture must serve as a sufficient guarantee upon this point, until time should have offered corroborative and conclusive testimony.

In general appearance, the Ransome stone bears such a perfect resemblance to the natural sandstones as to mislead the most critical observers, whilst the facility of application and its economy in use will have been apparent from the foregoing description. By the last-mentioned process the field has been widely extended for the useful application of the "apœnite" stone produced thereby. It is now no difficult task to produce blocks of this material of any form and of any size, the only limit being the means available for lifting them upon the spot where they are to be employed. Moreover, the greater part of the materials required for its manufacture are, as a rule, generally to be found in abundance where hydraulic or other important works are being carried on, and for which purposes this new stone is eminently suited.

The want of such a material for such purposes has long been felt, although that want until recently has only been partially supplied. In the year 1870, Mr. Jas. W. Butler applied for and obtained a patent, in England, for improvement in the application of concrete to structures and foundations, and also to coffer-dams and similar constructions. Mr. Butler's obvious desire was in the first place to provide a cheap and efficient substitute for stone for hydraulic operations, and in the second to render unnecessary the construction of false works, etc., and thus to avoid the expense connected with the employment of iron cylinders, hitherto so extensively used. The idea was certainly an excellent one, but its practical realization appeared very remote until Mr. Butler's attention was directed to the new "apœnite" stone, as a material necessary for the successful development of his proposed methods of construction. He accordingly communicated with the author upon the subject, and an opportunity was soon afforded for applying a practical test for the solution of this important question. Some extensive operations were at this time being carried out on the banks of the Thames in the construction of a retaining wall to protect the foreshore at Hermitage Wharf, under Mr. Butler's superintendence. Cast-iron cylinders, 8 ft. in diameter were specified to be sunk, to form the face of the wall next the river, and the work had proceeded towards completion when, in consequence of the strike on the part of the workmen, and the sudden rise in the price of iron, considerable delay and difficulty were experienced in procuring the iron cylinders. In this dilemma Mr. Butler suggested to the engineer-in-chief (A. M. Rendel, Esq.) the employment of cylinders of "apœnite" for the completion of the wall. The author was at once communicated with by that gentleman, and the order was given accordingly. The cylinders were 8 ft. external diameter and 9 in. thick, made in lengths of about 4 ft. each; when only a few days old they were sunk in the usual manner without any difficulty, and the result was so satisfactory to Mr. Rendel, that in a letter he wrote to the author on the subject, he expressed his regret that he could not have more of them. The following is the arrangement proposed for economically carrying out this class of work. A timber staging is erected, upon which the materials may be mixed and moulded, the moulds consisting of an inner and outer framing, the space between the two forming the mould for each ring for a cylinder or hollow block, as the case may be; the courses are joined by means of a cement formed of similar material to that of which the rings or blocks are composed. These are lifted from the staging on which they have been made, and lowered into position by an overhead traveller or crane, as may be most convenient. The lowest course of the cylinder or hollow block is chamfered, and when necessary, from the nature of the soil, may be shod with iron. The operation of sinking is carried out in a precisely similar manner to that adopted with iron cylinders. The horizontal joints are made with alternate projections and depressions, and the several courses are connected vertically by dowel piles, which also serve as guides in sinking the work. The application of this principle is capable of modification to suit almost every variety of construction, and it will be found especially applicable in structures requiring heavy foundations, particularly where the ground is uncertain or treacherous. For forming a face wall in building quays or docks, instead of cylinders, rectangular hollow blocks or caissons may be used. By employing hollow blocks of hexagonal form no interstices are left, a thin layer of the cementing material rendering the structure practically homogeneous.

Cylinders constructed upon this principle are also adapted for deep wells, apertures being formed in the sides for the admission of water. Turning to works of greater magnitude, it will be seen that "apœnite" forms a peculiarly suitable substance for the construction of bridges, sea walls, piers and similar undertakings. In the case of piers for bridges the structure can be carried up to the underside of the bridge girders or built with ordinary masonry above high-water level.

For sea walls or piers two rows of caissons are employed separately from each other longitudinally, the intermediate space being filled in with dry rubble hearting, and the blocks themselves with a similar material, or, if necessary, with concrete.

The author has recently inspected some works which are now in progress in this country, in which large blocks of Portland cement concrete are employed in the construction of the river wall. These concrete blocks, some of which are of the following dimensions, 14 ft. × 10 ft. × 5 ft. 6 in. = 77 cubic feet, weighing about 56 tons each, are moulded into form at a distance of upwards of two miles from the spot where they are finally to be deposited, and which, when sufficiently hardened, are transported by barges or floating derricks to their place of destination, where they are deposited in the ordinary mode of construction. If, in the place of these solid blocks of concrete, hollow blocks or caissons of "apœnite" stone are constructed, and after being placed in position were to be filled with good cement concrete, and backed with the same, the "apœnite" blocks being firmly bonded together, and the concrete forming one entire mass throughout, the structure would be perfectly monolithic, and so thoroughly compacted together that it would be impossible to disturb the position of one part without exerting such a force as would be necessary to destroy the whole.

In the case of an embankment for a reservoir, the heart of the bank, which is usually made with a puddle wall, is proposed to be substituted by two rows of "apœnite" cylinders, the contained spaces being filled in with puddle, and the cylinders themselves with material similar to that of which the bank is made. In sinking the cylinders they would be carried some distance below the natural surface, so as to obviate any chance of leakage below.

It is obvious that this plan could, without much difficulty, be applied to embankments already constructed where there was reason to apprehend that any settlement had occurred. By sinking the cylinders from the top through the puddle bank, but without removing any of the slope on either side, they would be carried down to sound ground, rendering the embankment safe, and removing all fear of danger in the future. A coffer-dam could be constructed under ordinary conditions at a cost considerably below that of any other effective material. It would not be difficult to multiply instances in which this material can be practically employed; but enough has aready been said on this point. An artificial stone combining the advantages of "apœnite," one moreover which can be so readily moulded into any form or size with but small expense and little or no delay, and, moreover, one that is practically "fire-proof," is necessarily applicable to a great variety of uses. The author will therefore only briefly remark upon its applicability for ornamental and decorative purposes.

When prepared with suitable materials, the "apœnite" is capable of receiving the most delicate impressions, and by the incorporation of the different metallic oxides any variety of colour can be imparted to it, so that artificial marbles or granites of almost every description can be produced. The artificial stones, like their originals, are capable of taking an excellent polish, are extremely hard, and can be readily moulded into the most elaborate forms at a very small cost.

The author would only briefly allude to the testimony that has been borne to the value of the apœnite process by engineers in England, whose names must be familiar to many of the present

company, viz. Messrs. Hawksley, Hawkshaw, Bramwell, Vignoles, etc. When the author had the honour to read a paper on the subject before the mechanical section of the British Association last year, the President, at the close of the discussion which ensued, remarked, "I cannot refrain from saying that I believe the process of making artificial stone which Mr. Ransome has invented and perfected is of very high importance indeed, that it has given to the world a new material which will be of great service, as well for the structural works of the engineer and architect as for purposes of ornamentation, and is eminently calculated to subserve many useful and important purposes in the industrial arts."

It now only remains for me to return my sincere thanks to you, sir, for affording me this opportunity of bringing my inventions under the notice of the members of this scientific institution, and to you, gentlemen, for the patience and courtesy you have extended to me in listening to the paper I have just had the honour of reading. I am aware that it contains many imperfections, which, however, I trust the subject of which it treats does not possess, but I must claim your indulgence, as it has been written in very great haste and without such materials at my command as I would have desired to enable me to illustrate the subject more fully. I, however, can only add, that I shall be happy to supply any further information in my power verbally that may have been omitted from the body of the paper, and to answer any inquiries that may arise in the course of the discussion which I understand is now intended to follow.

DISCUSSION.

Mr. HENRY CARTWRIGHT inquired of Mr. Ransome whether the artificial stone had ever been employed in the construction of piers for bridges or dock walls made in slabs set on edge, instead of in the cellular form.

Mr. R. replied that it had not been thus employed, as there would be some practical difficulty met with in that form, in securing the sides and ends of such blocks to retain the concrete filling.

The PRESIDENT.—In the manufacture of your apœnite, is not the peculiar soluble silicious earth employed that which is known as diatomaceous or infusorial earth?

Mr. R.—The so-called infusorial earth is excellently suited for the purpose, though we have found very suitable materials which bear no evidence of infusorial origin. In this country such deposits are quite frequent. It is found abundantly near Richmond, in Virginia, in the neighbourhood of Boston, and in several parts of California; and doubtless, should the necessity for its use become generally appreciated, it could be detected in numerous other localities. I must beg here to express my obligations to many scientific men, whom I have met in this country, and who have greatly aided me by sending samples of such materials for my investigation or by referring me to new localities where they may be found.

Mr. JOHN SARTAIN asked whether it was applicable to the sculptural decoration of the exterior of buildings, and to all that class of artistic work in which terra-cotta is now extensively employed in continental Europe. For example, bas-relief panels or slabs of ornaments or groups, whether in low or high relief. The inquiry had special reference to the sculptural decoration of an important building to be devoted to art purposes, now in course of erection in Philadelphia.

Mr. RANSOME replied that it was; that it had been used not only for enriching copings over doors and windows, but also for capitals of Corinthian columns, instancing a new hospital building at London, erected on the river bank.

The PRESIDENT.—Does the apœnite suffer any subsequent efflorescence?

Mr. R.—None at all. By the new process no washing is required, as is necessary with the "Ransome stone." So long as sufficient soluble silica and lime are present in the materials, the whole of the soda is combined, and thus none is left free to effloresce. At each successive chemical action which occurs during the process of formation, a portion of the free soda becomes fixed. It is therefore only necessary to observe carefully the correct proportion of the several ingredients before mixing, in order to insure perfect freedom from this difficulty. I may mention, also, incidentally, that the colour of either of the stones may be varied at pleasure. By employing a light sand a light coloured rock is obtained, with dark sand the reverse; or any colour may be imitated by the employment of suitable metallic oxides. If, in connection with the foregoing, it is remembered that fragments of various degrees of coarseness may be employed with the sand, it will be perceived that the appearance of any of the natural stones may be closely imitated.

Mr. WM. V. MCKEAN.—I should like to be informed of some of the mechanical details of the manufacture of the stone.

Mr. R. said that these were quite fully stated in the body of the paper.

Mr. —— inquired whether the chloride of calcium process was still in use.

Mr. R.—Yes, quite largely, both abroad and in the United States. One good reason for its continuance, aside from the fact of the quality of the stone, is that the plant is there. The last process (apœnite) is, however, beyond question, the best.

Mr. —— inquired how the stones stood the test of fire.

Mr. R.—Both the Ransome stone and the apœnite stand the fire well. They may be heated to redness without injury or material deterioration of their strength and hardness. The apœnite, however, seems to stand this test better than the other; in fact, so well does it act in this particular, that it would be quite practicable to make gas retorts of it.

Mr. ——. — What is the best material, with your process, for making the moulds for caps and columns?

Mr. R.—Plaster of Paris is found generally most convenient. Where we have our choice, however, and the nature of the work permits of it, we use wood.

The PRESIDENT.—Are emery wheels made by the last process?

Mr. R.—Yes; very largely.

Mr. SELLERS.—When the "Ransome stone" first began to be spoken of here, and the accounts of the method of working it were described in (I think) "Engineering," it seemed to me that the process might be utilized in forming emery wheels, which could be used either with water or oil. With this view we tried a number of experiments, and some wheels made by us on the Ransome plan were actually used in practice, but proved to have only a surface, wherein it is probable we did not get a perfect saturation of the chloride of calcium. We did, however, make some very pretty specimens of stone experimentally with various kinds of sand.

Mr. R.—The difficulty the President refers to was without doubt caused by the fact that, as the stone was made which he employed, the chloride of calcium was not made to penetrate into the interior, but simply affected the stone to a slight depth, while within, the same remained comparatively soft. Where the air-pump is employed, this material can readily be drawn through blocks of a foot or more in thickness, and this plan is invariably followed in the manufacture of this stone.

Mr. F. C. PRINDLE inquired if the stone was much used for drainage purposes.

Mr. R. replied that in most instances bricks and similar materials were found to be cheaper.

Mr. F. C. PRINDLE.—What is the relative cost of the two kinds of stone?

Mr. R.—The cost of the apœnite will generally be about two-thirds that of the "Ransome stone," but comparisons are difficult, inasmuch as this estimate will suffer many variations according to locality. Where the chloride of calcium can be obtained cheaply and in abundance, as in England, where it is a utilized waste product, the cost of the "Ransome stone" will be moderated; while, on the other hand, the cost of the apœnite will depend largely upon the abundance and availability of suitable deposits of soluble silicious earth, &c.

Mr. PRINDLE.—Is it more possible to use coarse sand with the apœnite than with the other stone?

Mr. R.—Coarse sand may be used with both. Indeed we are often glad to use very coarse materials.

Mr. EDWARD TILGHMAN wished to know the difference between the so-called Victoria stone and those described by Mr. Ransome, or if the Victoria stone was not an invention of Mr. R.'s.

Mr. R.—I am happy to say that it is not the same. I am, however, fully acquainted with the history and process of the invention of the Victoria stone, since the inventor is a personal friend, and I was consulted before the application was made for the issue of a patent, because the claims upon some points might be construed to conflict with those of my own patents. The inventor uses sand in connection with Portland cement; broken granite, &c., is also employed. The mould with the plastic stone is then immersed in silicate of soda solution. Thus silicate of lime is formed at the surface of the block. I do not wish to be understood as disparaging in the least the value of this process, since most excellent results have been achieved by it.

At the close of the discussion Mr. WASHINGTON JONES moved that the thanks of the meeting be presented to Mr. Ransome for his most interesting and exhaustive paper. The motion was unanimously adopted.

Mr. RANSOME, in acknowledging the vote of thanks, remarked that he had experienced so much kind attention from the members of the Institute, and such unexpected interest on their part in what he feared would prove uninteresting to them, that his thanks were due to them, rather than the reverse.

ECONOMICAL Evaporation.—GALLAND patents the use of a system of vessels connected together in a special way, so as to utilize the whole of the heat produced in the first generator: this is a steam vessel fed with distilled water automatically, the heat being transmitted through a series of vertical tubes, down which the heated liquors trickle. The crystals formed in the vessels are continually removed by the injection of a quantity of saline water greater than the evaporated amount, whereby all crystals and deposited matters are washed out into a settler of peculiar character.

By this system ten to eleven kilogs. of salt can be obtained per kilog. of fuel. *Bull. Soc. Chem. Paris, xx.* 330.

PROCEEDINGS OF THE AMERICAN IRON AND STEEL ASSOCIATION AT PHILADELPHIA,

NOVEMBER 20, 1873.

WE have before us the annual report of this Association which is interesting from many points of view. After being present at the meeting of the *English* (it seems now necessary to make this distinction) Iron and Steel Institute, held in London last April, we ventured, in our report of the proceedings and general view of the future of iron-making, to prognosticate that America would eventually be the successor of Great Britain in that production, which, after the manufacturing of cotton, has led to so much of our prosperity and wealth; and that this prognostication was a just and true one seems to be proven by some of the tables set forth in the Journal now to hand.

The constitution of the Association would appear to have been somewhat altered, and there is one feature in the present one which is very markedly different from anything in our own Association, where, if we understand correctly, the subscription is a fixed annual sum per individual member; and it is the assessment, by Article IV., of persons, firms, or companies becoming members of the Association, by a rate on the quantity of the production of metal at the various works. We are not quite sure that in the abstract this is a good plan, for to some extent it savours a little of an inclination to legislation of a very hard and fast character. On the other hand, it may be argued that the large manufacturer is likely to reap greater benefits from such an Association as this, than the small one, and that hence he should pay in proportion.

There is a distinction also made as to this rate with reference to the quality of the metal—pig-iron being charged one cent per ton of 2,000 pounds, one cent per ton on manufactured iron in any of its forms, two cents per ton on Bessemer steel, and two and a-half cents on other steel. There are also rates for the mining of coal, iron ore, &c., and for members engaged in the commercial sections of the trade.

The secretary's report commences with a general review of the iron trade of the world, for which we must give him every credit. Many of the tabular statements are of course extracts from other papers, notably amongst them "Rylands' Iron Trade Circular" and the official returns of European countries, others of which we have noticed before; but the features which attract most of our attention are the strong arguments used in favour of an increase of duty on the importations of foreign iron into America; a conservative protection which we scarcely expected to have met with in the writing of a citizen of the great free States. Pointing out that the aggregate value of American importations of iron and steel for the twelve months which ended on the 30th June last was fifty-nine million dollars, he proceeds to say: "We now see that these importations were not needed, and have done immense harm to the home pig-iron trade and all dependent upon it. An increase of the duty on pig-iron from $6.30 to $9 a ton, and proportionately upon other classes of iron and steel, would be a wise measure of relief for Congress to enact immediately after it assembles." We cannot possibly with our vast population afford to retaliate by a tax on American bread stuffs and provisions; but such a tax would unquestionably affect the American farmer, as the other corn and meat producing countries would then come into competition on more favourable terms, for our enormous demand. With reference to the exportation of machinery from America, we confess to being not a little surprised at the activity shown by the large number of locomotives exported during the years 1872 and 1873. From the Baldwin Works of Philadelphia, there were sent abroad in the former year 44, and in the latter 99, the value of them being $2,000,897.21. Now considering that the States are extending their own lines far more rapidly than any country in the world has yet done, this power of not only keeping up their own supply, but of actually exporting, is not a little surprising. We do not, in looking at the matter from this point of view, forget in the least how far the requirements of the American home market may have been supplemented, as no doubt it has been, by engines sent from Europe; but the fact in itself proves that there are fields in which before long we shall find our cousins formidable competitors.

The secretary of the Association further indicates—and, we think, very acutely—which these markets are; and when he mentions the West Indies, Mexico, Central America, we agree with him. He might, we think, have added the Asiatic coasts of the Pacific to this part of the list; but as regards the dominion of Canada, we have little doubt that it will so rapidly develop its own resources, which are magnificent, as to be independent both of Europe and the States. On the broad argument with which he next proceeds, that the extensive use of machinery enables the country which pays high wages to compete successfully with those which pay low wages, and use but little machinery, we apprehend that after all, this is merely a question of consumption and power to buy, as against excess of population, the consequent necessity of importing food and the keeping up of a large manufacturing population, which necessitates a lower rate of wage in order to pay in finished goods for what is imported as raw produce. That our position in England is rapidly becoming encrenitic there seems to be but little doubt in the minds of most of our thinkers, and during a late visit to Manchester and examination of some of the cotton-mills there, where certainly high wages are not always paid to the operatives, but where machinery is most extensively used, we heard the statement that no matter how great the improvements, low wages were the only safeguard of the employer. He can get over other difficulties by care and development of economy—but this is a stumbling-block of no small dimensions in his way.

In an article which appeared in this work some time back, we noticed the enormous weekly production of some of the American blast furnaces, and we have in the present report a statement that the Lucy furnace of Kloman and Carnegie Brothers, 75 feet high by 20 feet diameter of both, is actually running 575 tons a week of pig-iron. We are unaware that any production of this sort has been reached in England, but if it has we should be glad of some statistics of the burden, pressure of blast, &c., and shall feel obliged to any one who will be kind enough to send them to us. Another point on which we should be glad of details is that of the process pursued in connection with the production, in 1872, of 224 tons of peat pig-iron, and in 1873 of 1,600 tons of mixed peat and charcoal pig-iron. Our readers are well aware of how vast an importance we attach to the use of peat, both as regards the quality of the iron produced, and the general effect on the country of clearing away bogs; and we hope that some of our American readers who may chance to be in England will be able to afford us the information desired.

In speaking of the mineral resources of the Southern States, the secretary of the Association seems inclined to advocate the advisability, at all events for the present, of the ore mined there being sent to other sections of the country for smelting, a somewhat singular contrast to what goes on in our Cleveland district, where good coke is carried miles to poor ore, and yet is there profitably employed. Another feature in the report is the marked preference which is given to the pig smelted with anthracite over that produced from bituminous coal. We can, however, recollect the time when it was thought that anthracite could not be used in a blast-furnace at all; that time is, of course, past, but individually we are not as yet convinced that good clean clear coke made from bituminous coal is not the best mineral fuel in existence for the primary reduction of iron ores. Two analyses from the "Iron Age" of New York are given of the relative constituents of these fuels, which we append for the benefit of those of our readers who may not always have the advantage of seeing that journal:—

Average results of analyses of nine fair average samples of good anthracite from Wyoming Valley.

Moisture	1·38
Volatile combustible matter	3·52
Ash	3·24
Fixed carbon	91·86
	100·00

GEMS OF INDUSTRIAL ART.—CENTREPIECE BY M. ODIOT.

Sulphur	·220	Included in the above.
Phosphorus	·011	

Average results of analyses of six fair average samples of good anthracite from the Schuylkill Region.

Moisture	1·35
Volatile combustible matter	3·78
Ash	5·81
Fixed carbon	89·06
	100·00
Sulphur ·300 / Phosphorus ·024	Included in the above.

Average results of analyses of nine fair average samples of good anthracite from the Lehigh Valley.

Moisture	1·30
Volatile combustible matter	3·05
Ash	3·54
Fixed carbon	92·11
	100·00
Sulphur ·240 / Phosphorus ·005	Included in the above.

Results of analyses of a sample of Connellsville coke—an average of forty-nine different pieces.

Moisture	·490
Ash	11·332
Sulphur	·693
Phosphoric acid (phosphorus, ·013)	·029
Carbon	87·456
	100·000

The ash of the coke contained 47 per cent. of silica and 47 per cent. of alumina.

It is worth while to note how nearly in many particulars these tables correspond—the anthracites running so closely together that there is scarcely any choice left; but all of these seem to hold a certain advantage over the bituminous coal coke, which we confess somewhat surprises us, especially with reference to the ash in the last given as 11·332 per cent.—this ash containing 47 per cent. of silica and 47 per cent. of alumina. One thing, however, should be noticed—viz., that this superabundance of ash may arise from carelessness in coking.

A great portion of the rest of the Journal is taken up with tabular statements—all more or less showing the regular increase of the production of iron and coal in the American States; but so many of those which we considered of importance were abstracted in our notice of the report of the National Association of Iron Manufacturers for 1872, that it seems scarcely necessary to add them here. Both the Journals we have just reviewed, and that of the National Association, are valuable, we think, rather as records of trade than as scientific productions which will tend to the advancement either of the theory or practice of iron-making.

THE NAPLES CORAL FISHERY.[1]

LAST Thursday the Coral Fleet, or the great proportion of the vessels engaged in that arduous, though lucrative, fishery came in from the African coast. The rule observed is to suspend work on the vigil of the Madonna del Rosario, and neither for love nor money will the men work after midnight of that day. Their contract terminates then, and away they speed for Torre del Greco for the most part, whence the crews are distributed to their various homes all round the Bay. It was a pretty sight to watch the long line of boats with their white wings expanded to catch some impulse from the almost breathless air. All the day they remained in sight from west to east, and it was not until nightfall that they got into port. As a school for sailors none could be better than the coral fishery; and as every Italian is liable to be drawn for the Army or Navy when he arrives at the age of twenty-one, and as the sea is the favourite element of those who live on the Bay, every poor Neapolitan youth on the Bay is anxious to get his "Libretto," which exempts him from the army, and for the most part engages in the Coral Fishery. It is a hard service, but is a good preparation for the naval service. That, too, is a good preparation for the duties of after-life, as schools are established on most of His Majesty's vessels, and rude rustics when their time is up return to their homes licked into shape by the discipline they have undergone, and awakened from the lethargy of ignorance. But to return to the coral fishery; the captains of the barks send back their treasures at intervals by the vessel which is sent once a month from Torre with supplies. Thus, the risk of loss is more or less avoided, and, in spite of storm and shipwreck, some of the fruits, at least, of their labours, are guaranteed. This season has been very favourable, and at the beginning of this week, by favour of the proprietor of one of the boats, I was permitted to see all that his crew had taken. There were four chests locked and tightly roped, which had been sent home at intervals, and on being opened they presented a spectacle which few outsiders ever witness. On the top lay the fragments and the smaller, wormlike pieces; while underneath, protected against fracture, were the large and more valuable morsels. Every now and then a brawny arm was plunged in up to the elbow and a real treasure fished up. It is often said that coral—fine rose-coloured coral—is worth its weight in gold, and when made up it cannot be far from the truth. "This," said the captain, pulling out a handkerchief full, which had been stowed away in a corner, "will sell at 250 lire (£10) the ounce." It was of a beautiful pink colour, "and this," he added, putting a not very large branch in my hand, "is worth 40 ducats" (between £7 and £8). Altogether, the boat had taken 160 kilogrammes, or 5,920 ounces. Had the "take" been all of pink coral the profits would have been enormous; but much is of a very inferior character, and so a medium price is fixed. So many ounces of fine coral go to a certain weight of mixed coral, and if the season be good, as it has been this season, the speculation is very profitable. Fortunately, the season did not break during the fishery, so that all hands have returned safe and sound.

[1] From an occasional correspondent of the "Times," under date Naples, Oct. 17, 1873.

DIAMOND CUTTING—A NEW INDUSTRY IN NEW YORK.[1]

DIAMOND cutting is an art, not merely an industry, requiring that certain degree of deftness of manipulation which, after a few years of apprenticeship, is readily attained in nearly every mechanical operation; but a fine art in the full sense of the term. It is labour which calls not only for an exquisite refinement of manual dexterity, but an unerring judgment, to be gained only by hard study and constant practice, extending perhaps over a lifetime.

How Diamond Cutting was introduced in the United States.

We purpose, in the following paper, to tell the reader how this pursuit, now for the first time in the world's history followed in the western hemisphere, came to be established in the United States, and then to trace the various processes of diamond cutting as practised in the city of New York. It is a matter of general information that the art, from time almost immemorial, has been confined to the celebrated lapidaries of Amsterdam, Holland, whither the rough gems were forwarded from all parts of the globe. At the time of the extensive discoveries in the diamond fields of South Africa, however, Mr. I. Hermann, a well known jeweller of this city and an expert in the art, became convinced that diamond cutting could be introduced in this country, both as a valuable accession to the national industries and as a means of attracting large amounts of foreign capital within our borders. To this end he undertook its establishment in the face of many serious obstacles. There was an import duty of ten per cent. on the rough stones, the repeal of which had to be secured (a matter of no small difficulty, for the Government seemed unable to perceive the advantage of thus increasing the wealth within the country), large capital had to be obtained to start the enterprise, and, finally, workmen had to be persuaded to leave Holland and try their skill in a foreign land. When these men, in sufficient numbers, could not be induced to migrate, Mr. Hermann sought for other artists among the Dutch already in the United States; and he tells us that he found them pursuing all kinds of callings, in order to gain the support which

[1] From "The Scientific American."

DIAMOND POLISHERS OR SLYPERS.

the art they had studied all their lives was here unable to afford them. Then machinery was imported, only to be abandoned for entirely new inventions, also the work of the projector of the scheme; and thus at last staid old Amsterdam, to the dismay of her artizans, discovered that her long-kept secrets were known across the ocean, and her hitherto undisputed supremacy rivalled in the metropolis of the West.

THE MANUFACTORY.

We have thus briefly touched upon the organization of the New York Diamond Company, as a part of the history of the art in the United States, from which others in future will trace its growth. Success, we are told, has been encountered, as jewellers and owners of gems necessarily prefer sending their diamonds to a locality where they may be repaired or re-cut without undergoing the perils of an ocean voyage. Twenty thousand dollars worth of the stones, we learn, are received regularly each fortnight, while millions of dollars worth are yearly handled. The largest diamonds ever brought within the country, one of which weighed 80 carats, have, through the same agency, been imported.

We recently were enabled to visit this establishment, situated in a small building in Fifteenth Street, a few steps from Union Square, in this city, and there to follow the interesting operations which we are about to describe. As, in all descriptions, general explanations are first in order, we were at the outset informed that the business is divided into three entirely distinct branches—cleaving, cutting, and polishing. Also, that each class is a separate art, and that the workman finds the attainment of any one sufficient labour for the balance of his existence without troubling himself about the others. Hence, no one man can carry a stone through all the manipulations. A cutter cannot cleave, nor does a polisher know aught about cutting; and even further, a polisher or cutter of a brilliant cannot produce a rose diamond, and *vice versâ;* so that, in fact, each individual has his speciality, and there stops his knowledge.

NATURE OF THE DIAMOND.

The diamond itself, as all are aware, is nothing but carbon, a combustible body. It is crystallized mostly in the shape of an octahedron (two four-sided pyramids united at their bases) or rhombic dodecahedron, the latter being the commonest. In its black form—as used for stone drilling or sawing—it is the hardest known substance, and in this state differs from the jewel, which has foliated passages parallel to the faces of figure, in which directions it may be split. In the engraving fig. 4 is represented an enlarged section of the rough gem, showing the grain, along which it may be as cleanly cleft as a piece of wood. The resemblance to the latter substance is increased by the fact that there are so called knots, which cause a conchoidal instead of a straight clean fracture.

THE CLEAVER.

This much imparted by way of preface, we were conducted to the apartment occupied by the cleaver, or *klover*, as he is called in Holland. This artist, we were informed, must possess a greater degree of skill than any other workman. So difficult is his labour that probably there do not exist twenty-five cleavers to every five hundred polishers and cutters in the world. The *klover* in Holland is taught from boyhood, and is usually the son of the owner of the establishment, outside parties being

rarely instructed. On a small table in front of the workman was a little box divided into two compartments, the furthest containing a covered tray for the reception of stones. The other division was made deeper and had a false bottom, being finely perforated. Also on the table were a number of sticks like spindles, which, with a couple of knives (to which we shall presently allude), a metal rod for a hammer, a pair of scales, and a spirit lamp, constituted the entire kit.

Opening a number of little envelopes, each marked with a full description of its contents, the cleaver first put into our hands a quantity of rough stones. They seemed of irregular shape and varied in size, from that of a pin head to a large pea. Some pieces were quite flat and closely resembled mica. Selecting a diamond from the heap, the artist glanced at it a moment and then secured it in a knob of cement (brick dust and rosin) on the end of one of his spindles. Taking a fragment of a stone that had already been operated upon, he fastened it in a second spindle in similar manner. Next, with an implement in each hand, he brought the diamonds together, steadying the shanks of his tools against two metal projections on the edge of the box before him. Applying the second diamond to the rough gem, with a quick grinding motion he rapidly cut a notch in the latter; it was hardly the work of an instant, but the line was perceptible.

At this point our curiosity prompted us to ask explanation, and suspending his labour, the cleaver showed us that there were flaws in the stone which had to be cut off, and, besides, other pieces to be removed to give the gem its proper shape; so that probably, of the whole rough jewel, hardly one-half would be available. We looked wisely for the flaws but utterly failed to detect them, a fact not to be wondered at when we were informed by the artist that this ability constituted an important part of his art. "Indeed," he observed, "I have to know the structure of a diamond far more intimately than a physician that of the human body." As hardly any two stones are alike, and no rule can be laid down for the work, some idea may be gained of the consummate skill which enables a man to pick up a tiny fragment, glance at it once, and instantly detect not only flaws or streaks but where they are located, in the heart or on the surface, to make up his mind exactly what microscopic pieces must be removed, their size, and how they may be cut to turn them to best account, and, finally, how to so divide the stone as to produce the best colour. And all this so quickly, that although we saw half a dozen stones operated upon, we asked afterwards, When the workman had examined them? We had not noticed the single swift look given at each, as one after another was split by the artist as he continued his explanations.

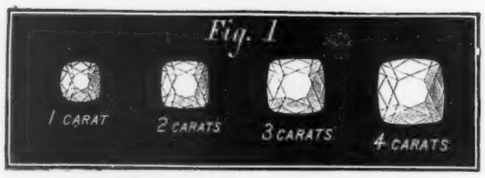
Splitting the Diamond.

We left the diamond, to indulge in the above digression, with a streak cut across it at the point at which it was to be divided. Placing the spindle containing the gem upright before him, the operator placed one of his knives directly over the cleft. The knife used was nothing more than a piece of steel, perfectly flat,

Fig. 4

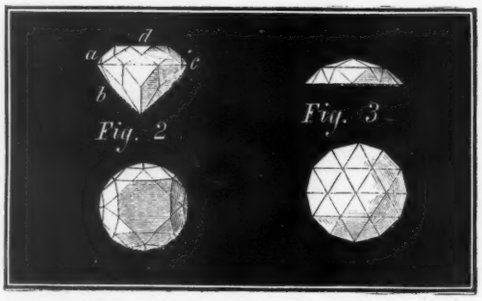
with a square edge, and about six inches long. It is ground blunt purposely, for if it were keen the hard stone would quickly turn the edge. Tapping the back of the blade lightly with his iron rod, the artist split off a fragment, and then, melting his cement and removing the parts, showed us a clean smooth cut (see fig. 4).

"But is not this a very risky performance?" we almost involuntarily exclaimed. "Suppose that you make a mistake?" The workman smiled superior, and explained that such is hardly possible, though he admitted that it would be a very easy matter to halve the value of a gem by a single false stroke. Imagine a $5,000 diamond—and that is not a large one—thus treated; $2,500 irretrievably lost by a single tap of the hammer! But then, with good sized stones, the work does not seem so difficult as with jewels no larger than pin heads, so small indeed that, in some cases, they number as many as 300 to the carat in the rough or 400 finished. An idea of the relative sizes, proportionate to the weight of the stones, may be gained from fig. 1, representing diamonds of 1, 2, 3, and 4 carats. Of course nothing is wasted; the dust that falls through the false bottom of the box we shall find again in the hands of the polishers, while the odd scraps are cut into rose diamonds, or the little sparkling grains used for inlaying initials and similar fine work in gold jewellery.



The Shapes in which Diamonds are cut.

Leaving the *klover* at his delicate labour, we were afterwards conducted to the cutter, or *snyder*. Three workmen were engaged in shaping the diamonds after the rough forms indicated by the work of the cleaver. Regarding these shapes a word is here necessary. The brilliant (fig. 2) displays the lustre of the stone to the greatest advantage, and is described as obtained by two truncated pyramids united together by one common base, the upper pyramid being much more truncated than the lower. *a* is the crown and *e* the collet, the two principal divisions formed by the girdle, *c*. *d* is the table, and the opposite side below, the culasse. The faces are called facets, and, including table and culasse, may number sixty-four. The rose diamond



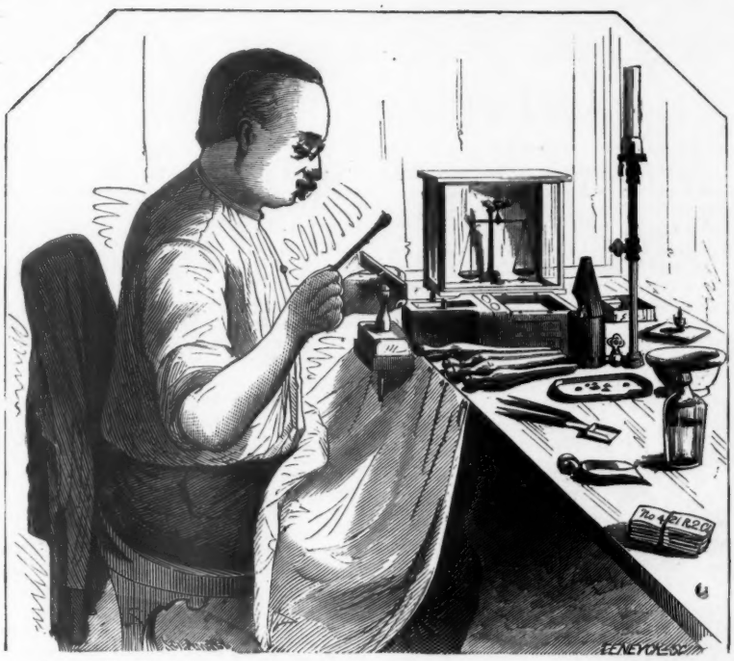
(fig. 3) has a crown but no collet, that is, one side is flat; and it is usually made from stones and fragments which would not, without loss, form good brilliants. Then there are table diamonds, which are flat and have little lustre, and bastard diamonds, or those of mixed shape. The brilliant and the rose are the general types, and those with which we have in the following description to deal.

The Cutters.

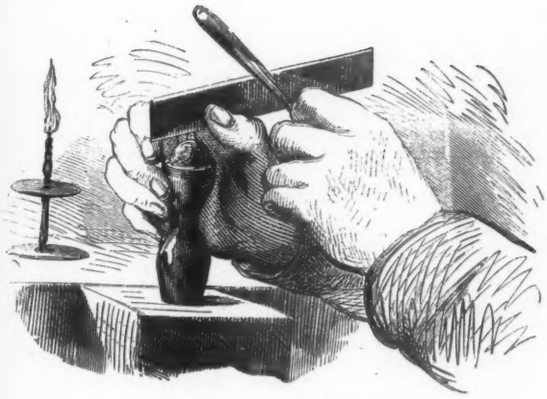
Our artist has graphically depicted the cutter at his work in the engraving. The same form of box used by the cleaver is before him, and the diamonds are fastened by cement, as before, in the ends of spindles. The cutter's labour is purely "diamond cut diamond." The stone to be cut is held in its setting firmly in the left hand, while the cutting piece is moved by the right. Both gems are of course affected by the mutual abrasion, but the attention of the workman is directed to but one. Very slowly the faces are ground away; no measurements are taken or angles calculated. The eye is the only guide, and it seems to be a faultless one. As soon as the first stone was finished, the diamond used for cutting it is operated upon, so that diamond No 2 is, in turn, cut by No. 3, this by No. 4, and so on. Again the gems were handed to us for examination; all their mica-like sheen was gone; and, were it not for their form, they presented no different appearance from rough quartz pebbles. The friction dulls them, for they are ground together with considerable force, the workman being obliged to protect his hands by thick coatings against the rubbing action of the tool.

Polishing the Diamond—The Setter.

The polishing operation next claimed our attention; and ascending to an upper story, we found the polishers or *slypers* at their work, each man with a machine before him, as represented in the engraving on the preceding page. In addition

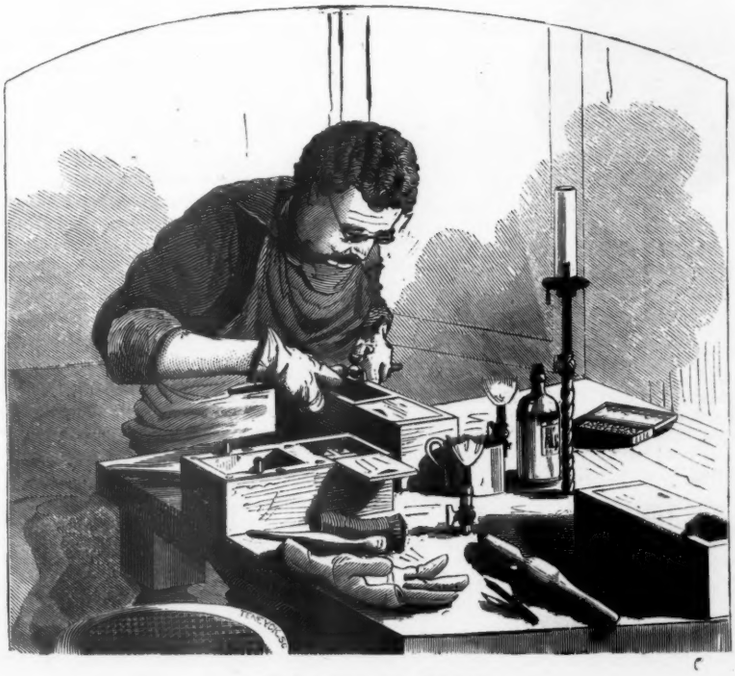


THE CLEAVER OR KLOVER.



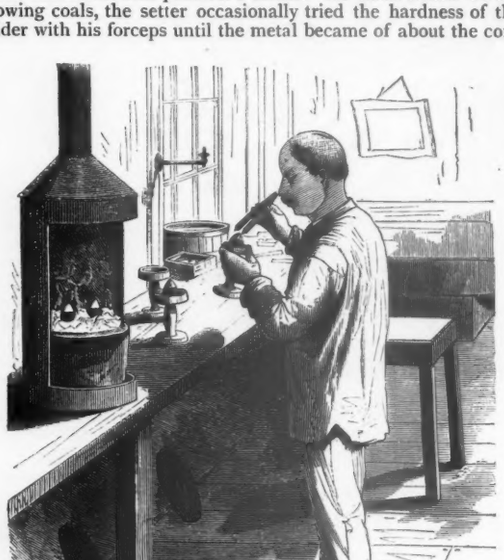
SPLITTING THE DIAMOND.

CUTTING THE DIAMOND.



THE CUTTER OR SNYDER.

to these workmen is the setter, and with him we have first to deal. At one side of the room was a small charcoal furnace in which a number of metal acorns seemed to be roasting. Each of the latter consisted of a copper cup about an inch and a half in diameter, provided with a stem of stout wire of the same metal and filled with plumber's solder. As these rested on the glowing coals, the setter occasionally tried the hardness of the solder with his forceps until the metal became of about the con-



THE SETTER

sistency of putty. Quickly removing an acorn, or, to use the technical name, a "dopp," from the fire, he placed it upright in a small stand. Then he fixed a diamond exactly in the centre of the plastic metal, and, with his fingers, coolly moulded the latter in conical shape around it. Burning seemed to have no terrors for him, and although when the dopp was plunged in water it hissed at a great rate, the hand of the workman showed no effect of the heat. Each brilliant, large or small, has to

THE DOPP.

undergo this operation once for each facet; that is, the setter must reset it so that every one of its facets in succession may be exactly horizontal and outside the holding metal, in order that each face may receive its proper polish—an operation requiring no small amount of delicacy and skill.

THE POLISHERS.

Again referring to the engraving on page 139, the polishers were seated before long tables, on which were swiftly rotating horizontal discs fastened on vertical spindles, the lower ends of which revolved in antifriction steps. The discs, we were told, revolved at the rate of 2,000 turns a minute, and yet the bearings kept perfectly cool. The machine is an invention of Mr. Hermann's and an improvement upon the old apparatus used in Amsterdam, a specimen of which he exhibited to us. The construction of the latter seemed very rude and primitive, being formed almost entirely of wood; the bearings, it is stated, were continually heating and wearing out.

The discs or *shives* are circular plates of a composition containing both iron and steel, and are made and turned in the establishment. They are ground in lines, at an angle from centre to circumference, so as to hold the oil and diamond dust used in the polishing operation.

Three diamonds, set as above described, are ground at once by each polisher. The stem of the dopp is fastened in tongs or clamps, the extremity of the latter being supported by legs an inch or so high. Two thirds of the dust ground off in the cutting is allowed to polish each diamond, and this, mixed with oil, is applied to the stone by the quills which the men seemed to be phlegmatically chewing. The adjusting of the gem on the disc requires wonderful accuracy in order that exactly the proper facet be ground and no more; for the slightest mistake might cut away an angle and produce serious damage to the stone. The reader will share in the astonishment we felt on learning that this extremely delicate work was done by feeling. So sensitive is the touch of the artist that he tells by pressing on the stem of the dopp exactly whether it lies true against the shive or not, and by his fingers adjusts the stone over incredibly minute angles and distances. This goes on until each facet is brought to the requisite brilliancy. Standing by one of the machines, we saw, as the diamond was removed from time to time from the disc, the bright spot on its dull face gradually enlarge, as heavier weights were put upon the tongs to press the stone with increased force against the shive. Sometimes the gem defies all efforts, the hard outer coating refuses to yield, and then it is passed from hand to hand, and for weeks each workman tries to conquer it. Sometimes they fail; at others a bright spot at length appears, and the difficulty is over.

RENEWING INJURED STONES.

It is to this portion of the establishment that injured stones are sent for repairing. We were shown a number of diamonds that had been through the Chicago fire. They had become intensely heated and then suddenly cooled. A white hard film had formed over them, necessitating as careful repolishing as the unfinished gem. We were told that it is a common fault among jewellers to thus hurt the stones during the process of setting them. The difficulty can be easily avoided by allowing the diamonds to cool gradually instead of plunging them at once into cold water. It is the sudden transition and not the heat that does the injury.

ABOUT THE WORKMEN AND THEIR PAY.

Our examination here concluded, for polishing is the last process. The workmen, numbering thirty-five in all, we learned, were all Israelites, and with the exception of the cleaver, were paid by piece work. Their wages reach from 60 to 200 dollars a week, depending on the skill and experience of the artist. The greater number of carats manipulated and the more diamonds there are to the carat, the higher the price paid for the work. The establishment is necessarily organized with great strictness, and every diamond is weighed, registered, and fully traced throughout its entire course. Large and valuable stones, before being operated upon, are made the subject of a consultation between the head of the company, the cleaver, chief cutter, and chief polisher. Each gives his view, and thus the question of shape, colour, &c., is carefully determined.

WHERE THE DIAMONDS COME FROM.

The diamonds are principally imported hither from Brazil. South African gems have caused no very marked effect in the market. They are fine, but, it is stated, more difficult to cut than those from South America. The Arizona swindle created considerable excitement when the first "salted" stones reached the trade, but of course the dismay of the diamond merchants was allayed when the fraud was exposed.

DIAMOND CUTTING IN ENGLAND.

We notice that diamond cutting has recently been introduced in Birmingham, England, where there is every prospect of the art reaching a flourishing state. Recent advices also inform us

PORTABLE RADIAL DRILLING MACHINE.

that a huge diamond has been discovered and brought from the Cape. It weighs 288¾ carats in the rough, and when cut will be half as large again as the world-renowned Koh-i-Noor.

PROSPECTS OF THE ART.

We see no reason why the art which we have described should not grow in this country to be an important branch of national industry. To Mr. Hermann, now the President of the New York Diamond Company, a corporation of wealthy gentlemen, founded by himself, belongs the credit of its establishment among us, and the consequent enabling of the artizans of the United States, who may be instructed in his *atéliers*, to compete with and successfully rival the monopoly which, for centuries, has maintained an exclusive and undisputed supremacy in the Old World.

PORTABLE RADIAL DRILLING MACHINE.

WE illustrate above what appears to us to be a very useful and convenient tool—viz. Thorne's portable radial drilling machine, the manufacturers of which are Messrs. Easterbrook and Allcard, of the Albert Works, Sheffield; and we feel the more inclined to do so from the fact that wherever they can be made applicable, the tendency of the practice of our engineers is to avail themselves of portable rather than fixed machines. We do not for a single moment contend that there are not hundreds of instances in which portable tools such as is the one under notice would not be almost valueless, but we believe at the same time there are hundreds of other instances where they may be made of such an

essential use as to be of great benefit to a manufacturer; indeed, if we only look at the question in an abstract sense, it is somewhat readily apparent that the portable tool approaches not a little nearer to the actual human artizan than does any instrument being a fixture, and hence we regard the employment of these movable machines as a decided advance (where they are well designed) in the practical mechanical science of the day.

The cut we give indicates pretty plainly the action of the drill, in placing which it is advisable that the driving apparatus should be as near as possible to the centre of the area in which it is desired to use the machine, and the straight or plumb edge of the hanger should be towards the shaft from which the power may be taken—the belt from the line shaft so acting that the large V pulley will in revolving draw the round belt up through the hole in the swivelling frame stud. To start the apparatus the round belt should be passed over the large V pulley, then down through the hole in the swivelling frame stud, then under the small V pulley, in a line with the hole, then to the drilling machine, then back over the other small V pulley, and then down under the weighted V pulley, after which couple. The base of the drilling machine is intended, as may be seen from the engraving, to be bolted or clamped to the piece to be drilled, and the height of the post can be adjusted to suit the different length of drills and chucks used in the spindle. The radial slotted arm being fastened to the post by the stud and nut—the position of the drill can be adjusted by the screw which causes the arm to travel, and the worm and tangent-wheel which give it rotation on the post. The operation of the tool is then as follows:—The counter hanger is bolted to the ceiling or any other convenient place, and receives power from the "line shaft" by a flat belt on the fast and loose pulleys. The frame carrying the "idler" rotates on a hollow stud through which the round belt passes to the grooved driving pulley. The rotation of this frame permits the belt to be led to the drilling machine in any direction radially from the hanger, while the rise and fall of the weighted "idler" permit it to be led to any point within the scope of this rise and fall—say from ten to fifteen feet, or more, and by inserting sections of belt by means of the hook couplings any distance can be reached. The tool, as we have sketched it, will drill up to 1¼ in. diameter, the spindle being of 1¼ in. steel with 6 in. feed, the post having 6 in. of vertical adjustment, and the radial arm rotating the point of the drill through a circular area of 43 in. diameter by means of the worm and tangent-wheel.

When it is required to drill parallel with the base, the post is held by the clamp bearing on the side of this base. There is also a shoulder turned on the bottom of the ball on the gear-frame, and a half collar fitted to it and bolted to the arm which keeps the spindle square with the base. On this half collar being removed, the spindle can be set to an angle in any direction. The relative advantage of drilling or punching is, as our readers know, so far as boiler-plates at least are concerned, still a *quæstio vexata;* but be that as it may, the tool we have just been describing seems to us a useful one, and one which, having regard to its comparative portability, may certainly be looked upon as an advance in practical mechanical application.

BERRYMAN'S PATENT STEAM TRAP.

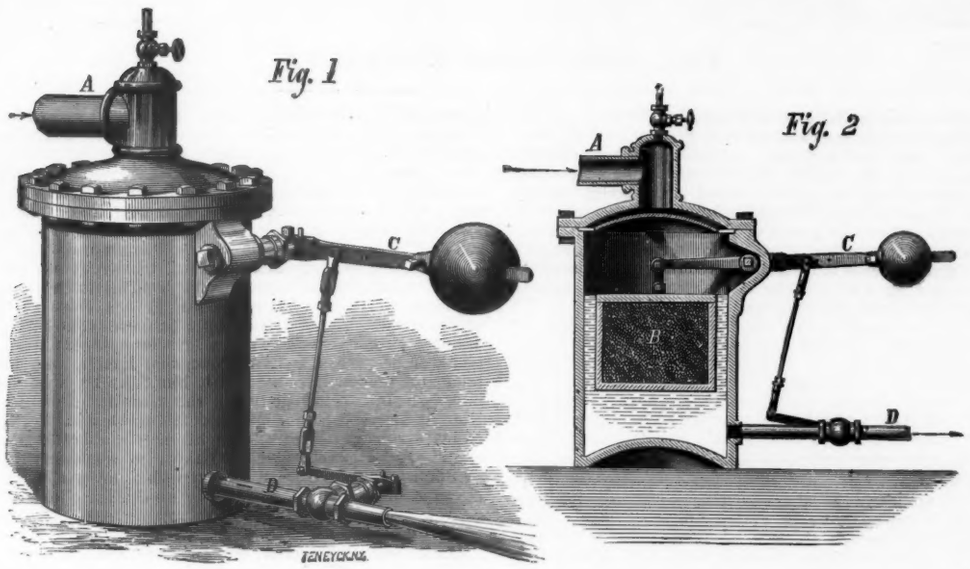
STEAM is now so universally employed in manufactures and for heating purposes that various provisions have become necessary, in order that the steam and its contained heat may be economized and utilized to the greatest practicable extent. One of the principal points demanding the attention of the engineer who fits up a factory or other building with a series of steam pipes, is the collection of the water that must accumulate in the pipes, from the condensation of the steam passing through them: the means employed to withdraw the water must provide for that withdrawal without interruption to the flow of the steam through the system of pipes, and without permitting any waste of the steam. Various devices have been tried for this purpose. Brass expansion tubes and copper floats have occupied a prominent position in most of these contrivances, but the injury to the delicate action of the tubes, caused by deposit, allowed steam to escape with the water, while the danger of the float ball leaking and filling up with water causes great uncertainty of action in such contrivances, and renders them practically valueless.

Machines used for the withdrawal of water condensed in steam-pipes are called steam traps, and the steam trap we now illustrate and proceed to describe is the invention of Mr. R. Berryman, of Hartford, Conn., U.S.A., the inventor of the patent feed water heater, illustrated by us in a recent impression. Fig. 1 shows the trap in perspective, and fig. 2 in section; it was designed to overcome those defects referred to above as being inherent in other forms of steam trap, and to provide a trap alike simple and strong. Referring to figs. 1 and 2 the steam is conveyed from the steam apparatus to the trap through the pipe A. B in fig. 2 is a bucket float, suspended from the lever C; this lever vibrates on a pin or rock shaft, of which one extremity passes out through a stuffing box, and the other portion of the lever C is secured to it; this latter has a weight so attached to it as to be adjustable in order to modify its leverage over the float within the trap. This outer part of the lever is connected, as can be seen in the sketch, with a cock fitted to a pipe D, at the base of the trap—the little tap seen at the top is to provide for the expulsion of air. The action of the machine is simple. When the trap is empty the float inside overbalances the weight outside, and raises the outer lever, the connecting rod, and the lever of the cock on D, which is thus closed; the drip of condensed steam into the trap gradually fills it with water, and, as this rises around the bucket, the latter at last floats up as the chamber fills; in rising it lowers the balance-weight—and its lever outside, the cock on D is opened, and the water blown out by the steam pressing it behind. The trap being half-emptied, the float falls, raises the outer lever, and closes the cock. The power exerted by the ordinary float equals, of course, the weight of water it displaces, so that, if the bucket used as a float in this steam trap measure a cubic foot, then it would displace 62½ lbs. of water, or else, if the trap were quite emptied, it would exert a downward force of 62½ lbs., and thus between this bucket within and the adjusting weight without the inventor claims a delicacy of action in the machine equal to that of a scale beam; adapting itself to all conditions, and discharging either large or small quantities of water, as occasion may require. If the condensation of steam takes place at a given rate, then the bucket will keep at such a level as to permit of a certain uniform discharge of water.

Mr. Berryman has devised a method of fitting his steam trap to steam boilers in such a manner as to make it available as a feed regulator and alarm. The large illustration (fig. 3) shows this arrangement. With fuel at its present ruinous price every contrivance for utilizing heat that would, without special arrangements, be otherwise wasted, becomes worthy of attention, because a good heat-saver pays for itself in a very short time; one of the essentials to save heat is the regular supply of the feed water to the boiler; when a boiler is over fed with water all the evils of priming, the injury to cylinders and valves from dirt and grit passing from the boiler, the waste of heat caused by using wet steam, by the necessity for keeping the cylinder cocks open to let the priming water escape; all these evils cause loss of heat and injury to machinery and fittings. Mr. Berryman then designed the regulator and alarm we now proceed to describe in order to obviate these evils; it embraces the double purpose of regulating the feed, and of giving alarm by opening a whistle should the water from any unforeseen cause get too low. For a section of the machine we refer to fig. 2 of the steam trap.

The bottom of the cylinder A is set 6 inches below the feed or true water level, and the pipes B and C connect the interior of the machine with the interior of the boiler; B connecting the top of the cylinder to the feed line, while C is connected at any convenient point below the water line, and conducts the water back to the boiler at each change. In the casing A is a bucket which is suspended from one end of a lever, which lever is secured to a shaft which passes through a stuffing box to the outside of the cylinder A, and the bucket floats and actuates the parts connected with it, just as in the steam trap described above. The outer lever D acts on and controls the suction valve of the feed pump, increasing or diminishing the supply of water pumped into the boiler; or the regulator can be fitted to control the feed valve of any apparatus which works by utilizing some external pressure greater than the boiler pressure, to force the water into the boiler.

The operation of the regulator is such that when the boiler is supplied with water so as to cover the inlet of the pipe B on the feed-water line (steam having been raised, and the air blown out through the cock on top of the casing A), the casing will be immediately filled with water. The bucket inside being thus submerged the displaced water will raise the bucket and depress the lever D, and wholly or partially close the feed-water valve, the latter being adjustable by a right and left screw on the connecting rod. Whenever the water level in the boiler falls below the inlet of pipe B on the feed-line, steam enters and fills the upper part of the casing A, and the water above that line



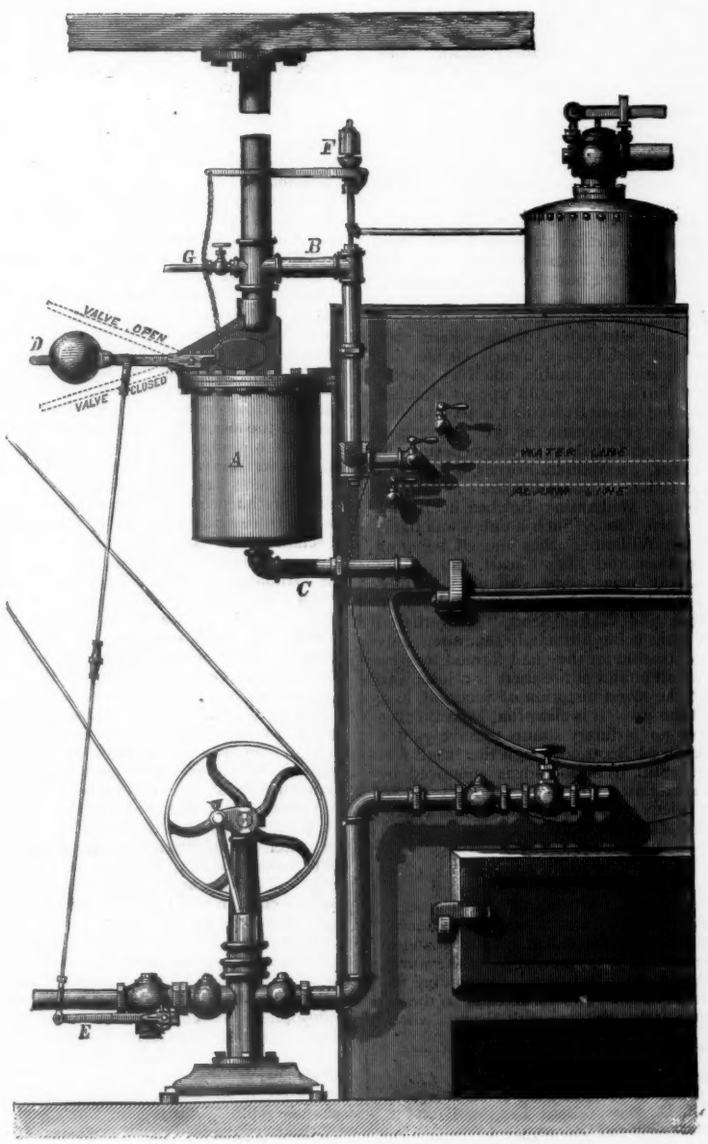


FIG. 3.

BERRYMAN'S PATENT STEAM TRAP.

can then fall by gravity back into the boiler through pipe C. Then the water having regained its level the bucket falls, lifts D and E and opens the feed valve. Should the water-supply be so reduced that the evaporation exceeds it, the water-level being the same in both the cylinder A and in the boiler—as the water-level falls the bucket falls with it, until the short end of D opens the alarm whistle by means of the connection, this latter being adjustable so that the alarm can be set to sound at any water-level desired, below the feed-line ; and the gradual increase of whistle-sound gives ample time to avoid an alarm, provided water is supplied in proper quantity.

JAMES DAVID FORBES.[1]

A TRIPARTITE authorship is an unusual circumstance, but not entirely without precedent. The mountains of labour existing in the form of books, deprived, however, of that delicate essence which recommends them to an immortality in the Republic of Letters, were frequently divided and subdivided until all original intention seemed lost, and hence the floods of a literary Lethe closed over them, and they were forgotten—the contents, good and evil, alike forgotten. In the present instance it is to be seen whether the work before us merits or demerits the careful attention of the reading public. Biographies, as has been repeated with almost nauseous repetition, ever contain in them the most alluring form of reading, and, when, as in the present instance, letters and records depicting the man as he wrote and thought, are added, the book itself assumes more of the autobiographical form, and hence it is exquisitely interesting to us. In the "Life and Letters of James David Forbes" there was, however, a special reason for a tripartite authorship. The work he did in the world—although not equalling in gigantic scope the labours of a Humboldt, was of a nature demanding the elaboration of more than one hand. And again, the familiar details of personal history required an attention the pure man of science could not bestow ; while scenery of a pictorial character could not be more safely entrusted than to one familiar with the places to which allusion had to be made. Hence it is that we obtain an admirable volume where each phase of an important, because useful life, is clearly visible.

The family of Forbes was ancient and noble, allied by descent to the chiefs of the house of Forbes. It would appear that the second Baron Forbes, who died about 1460, had a second son, Duncan Forbes, of Corsindie, the ancestor of the Forbeses of Monymusk and Pitsligo, in Aberdeenshire, of whom in turn the father of James David Forbes, Sir William Forbes, of Pitsligo, was the hereditary representative. Young Forbes was born in Edinburgh—his mother being Williamina Belches or Stuart, Lady Forbes, on the 20th April, 1809. Such a union was likely to produce a happy result, Sir William Forbes himself being an acute man of business, of a warm and liberal heart, and a mind cultivated by sympathies with what some call old-fashioned Tory ideas. Perhaps this will be more intelligible if it be mentioned that William Forbes and Walter Scott "foregathered together" as boys and as men, being ultimately separated only apparently by the common attachment they had formed to Miss Williamina Belches. As in all affairs of life there is a loser and a winner—so Walter Scott, the loved historian of Scotland, lost, and William Forbes gained the lady. It is clear that Miss Belches must have been a person of no ordinary stamp to have gained the affection of such a person as Scott, although the result was that she married another. Still, from the ideas enounced by Keble, the lady must have exercised no slight influence on Sir Walter's career. As it is briefly said in the volume before us—it is but "one instance more of the old truth that poets

"Learn in suffering what they teach in song."

This lady, then, was to be the mother of James David Forbes.

He was the youngest of six children, and it has been observed by the curious in such matters, that the eldest or the youngest usually achieves the greatest amount of reputation in the world, owing, perhaps, to some subtle sympathy with surrounding nature not to be readily understood, but still most clear to the reflective mind. This is particularly the case with Forbes, whose keenest sympathies with nature in its grandest glacial forms, its proudest astronomical trophies of the firmament, and its minutest microscopical forms of life, endured to the end of his life. It is very doubtful whether the man who loses his mother in infancy, or who retains her through manhood, is most likely to achieve fame. In Forbes's case, he lost that dear and confiding sympathy which tempers the waywardness of genius at an age when it might be supposed the mind was little impressible. Yet the loss seems, in his individual instance, to have refined and chastened his mind, without deteriorating from his manhood or dwarfing his intellect. To his affections the lost, dead mother, possessed by him but for a year and a-half, ever continued present, and in his twenty-sixth year his love brought him back to the place of her death, at Lympstone, near Exeter, with the same fond and tender love born with him. As his sister writes of him, "An intense sensibility to the associations of the past, a clinging fondness for the scenes of his youth and the memories of his early days, were among his most amiable and abiding qualities. Little relics, which many men would have despised as childish, were preserved by him with a loving appreciation of the value once attached to them. And this taste for the simplest and most innocent pleasures he retained unimpaired to the last."

Under such melancholy circumstances there is little wonder that Sir William Forbes regarded his youngest born with no ordinary feelings of affection; and affection, joined to a right mind in the object loved, will beget a feeling of trust and an emulative desire to excel. Join to this a great faculty of wonder and curiosity, and you behold in the little child, indeed, the father of the future man of science. Again to quote a line or two of Miss Forbes's sketch :—

"This summer (1811) was rendered memorable by the appearance of the far-famed comet, which no one who ever saw can forget. Its sojourn was long, and night after night was the infant philosopher danced at the window in full view of the glorious phenomenon, its splendid tail seeming to sweep across a quarter of the heavens. His brothers and sisters pleased themselves in after years with the fanciful imagination that some secret inspiration was thus communicated which never lost its influence, but continued ever after to lend an irresistible attraction to the study of the heavens."

It is not designed here to dwell upon the childhood of Forbes further than it is necessary to show that events and parents, on either side, combined to form a man of remarkable and interesting character. What is termed sensibility made him to a great extent weak, but this was balanced by a mathematical love of detail, inherited from his father, an uprightness of conduct to be deduced from both sides, and an infinite longing for a knowledge of the interrelations of things, that gave strength in proportion to the weakness. It may be said, indeed, that the infinitely little is as important as the infinitely great; hence the microscopist, such as a Leuwenhöck; or a cosmist, such as a Humboldt, are but working with the same tools in actually the same field. In our own days, as in the days of the early Egyptians, specialism and continual subdivision has come to be the rule. To know one thing certainly has been found a practical rule in the estimation of men. To grasp at all is a thing so utterly strange, that what is called mediocrity regards it with unbelief, and denies it the sanction of society. Professor Forbes, as we may now call him, combined a portion of all these aspirations in himself; but seeing his utter incapacity to retain all the knowledge he had gained, he abandoned some portion of his desires for the improvement of the rest of his faculties. Hence, instead of being regarded by the best authorities as a wild visionary, he died the respected chief of an honoured and honourable university. There was a good sense beneath, that good sense shown everywhere in his correspondence and other documents—his confidence in God. Perhaps, for a scientific man, no letters are so replete with feelings of religion, of the true and proper kind, not the delusive and the sham. It has been the endeavour of the writer to analyze this character for the purpose of correcting some errors formed, by want of thought, in relation to great men. The Professor cannot, however, be regarded as a man of the first class in every sense ; truthful, honourable, and tolerant, there seems a certain passivity shining through his labours entitling him only to a second-class place in the scientific world. We propose to justify this expression when we come to examine his absolute addition to our stock of knowledge.

Very curious and interesting is the expression of the youthful philosopher, "related" (we again use the words of Miss Forbes, whose reminiscences form the gem of the whole book) "many years after by an attached old servant, who happened to be in the nursery when Sir William came in and asked all his children what he should bring them from London. The youngest instantly replied : 'Bring me a telescope, papa.' 'Ah, Jemmy,' was the reply, 'you'll never make salt to your porridge.' 'But

[1] *Life and Letters of James David Forbes, F.R.S., D.C.L., LL.D., late Principal of the United College in the University of St. Andrew's.* By John Campbell Shairp, LL. D., Peter Guthrie Tait, M. A., and A. Adams-Reilly, F.R.G.S. Macmillan and Co., 1873.

he has made salt to his porridge,' was the triumphant comment, 'for he was the pride and darling of the whole household.'"

The observation was justified by the subsequent high position attained by "Jemmy;" but is it not rather of a piece with all the other fond and industrious predictions and trifling expressions of well-kept and properly nurtured domestics? If Professor Jemmy, who would have a telescope, did not "invent gunpowder," he at any rate did something in the peaceful warfare of science, and illustrated the glaciers. To those who believe in such things, there was a strange kind of vaticinatory power or "forecast" in the old nurse's words; as underlying science, in a distracted, almost unreadable way, there ever exists something of the secret and occult, precisely in the same way that theory becomes practical—that the subtle thought is realized in the solid, labouring engine. To employ a form of speech, the apparent unrealities of a Euclid are concreted into the actualities of a Stephenson, an Arkwright, or a Wheatstone.

This, however, is a process necessarily accomplished by self-application; and the experience of the writer, which has enabled him to mix much with students of abstract mathematics, has shown that of all classes of thinkers, mathematicians, from their very isolation of ideas, usually develop into unpractical and self-assertative men, unfitted for the common and more realistic duties of life. There is, in fact, an arrogance of mathematics often culminating in mental aberration or exaltation of a kind most sad to see; it is a very general characteristic of persons devoting themselves solely to the contemplation and investigation of abstract topics. Hence the greater necessity for a balance of religious principle.

"An undevout astronomer must be mad."

This religious principle, however, existed in a large degree in Professor Forbes, and illustrates his whole life. He seems, in these early days of his, to have been a singularly quiet, studious but cheerful lad, when not actually engaged in unconsciously preparing for the special pursuits of his after life. Our authors very happily summarize his early disposition in the following words:—"The high quality of his race was conspicuous in him from the first. Strong and sterling fibre and a lofty bearing were combined with tender and delicate feelings not often found in so vigorous a character. But whatever may have been the hereditary basis of his energetic nature, it was no doubt intensified by the peculiar surroundings of his childhood and youth. Seldom is a boy of his birth brought up in more complete domestic seclusion. The widowed and heartbroken father, after his wife's early death, withdrew to almost absolute retirement, which, while it was congenial to his own feelings, enabled him to devote himself more entirely to the rearing of his children. This devotion was especially concentrated on the youngest, who became his father's idol, as the last legacy bequeathed to him by her whom he had lost. His home at Colinton House enabled him to seclude himself more completely than most places so near a great capital. Lying not far from the base of the Pentlands, approached by tree-shaded lanes and by-roads, itself shut within its own park by old trees, with a garden screened by still older holly hedges, wonderful for their size, with an ivy-mantled ruin in the grounds, said to have been rent in pieces by Cromwell's cannon, and with a retired background which sloped to the water of Leith, as yet undisturbed by the railway whistle, and it would be hard to find in so peopled a neighbourhood so solitary a retirement. The boy's not too strong health and the father's anxious watchfulness secluded him still farther, and made school a thing not to be thought of. The family at Colinton were their own society; the visits even of relations were rare, and there was little or no contact with the world beyond. Such a mode of life, acting on a nature itself strong and intense, could not but increase and concentrate still more that intensity which was ever afterwards its most marked characteristic. The stream, confined from the very first within high and strong embankments, channelled still deeper the groove in which it naturally ran. James Forbes never went to any school, but was entirely a home-trained boy. Up to the time he entered college, at the age of sixteen, his only teachers had been his sisters' governess and the village schoolmaster, Mr. Hunter, of Colinton parish school." It was thus the future professor made his way into the rudiments of education; and, self-impelled, his mind turned to natural science with the ardour of a young and intellectual disposition. According to some notes left by himself, he employed his leisure in mechanical experiments, and crude though original attempts at philosophical instruments for various purposes. He says especially of himself:—"About the same and at a later time I took great pleasure in organizing and conducting societies partly composed of imaginary members, a certain number of names being apportioned to myself and to my kind brother Charles for debates and reading papers on literary and scientific subjects, with occasional experiments, and all the formalities of meetings and constitutions"—a singular but not unnatural taste on the part of our solitary young philosopher, forced to create a world of science and business for himself amidst the sylvan glades of Colinton. He also took great delight in imagining and delivering lectures in a methodical manner, with no audience save the creatures of his own imagination. No doubt this was, however, valuable training for one whose life was afterwards to be spent in actual pursuits of a professional character.

Nor was this the only method in which Forbes, so to speak, educated himself. At the age of twelve he amused himself with efforts towards journalism, in the literary acceptation of the word. He mentions the "Telescope," the "Hebdomadist," and the "Adelphi Magazine," as being among these early literary productions. He also kept regular registers of the barometer and thermometer—all evincing a mind prone to method, and no doubt inherited from his father. This bent is quite evident, and it is fortunate that he was enabled to pursue his inclinations without that check placed by some parents upon the tastes of their offspring.

As to the choice of a profession, it would seem that at first he was strongly disposed to devote his life to the English Church, but subsequently he deferred to his father's wish, and began to prepare himself for that favourite pursuit of the Scotch mind—the Bar; but during the whole of this period he continued ardent in his pursuit of science, devouring every scientific book he could obtain, from the "Nautical Almanac" to Woodhouse's "Astronomy." Meteorology and astronomy were darling pursuits which he consistently followed up, and his journals and diaries of early youth were preserved by him to late years, and occasionally examined with curious and scrutinizing eyes. Those who have preserved such early and incomplete records often experience singular and mixed feelings on their re-examination. How many things have remained little altered, and how many have utterly died away in the grown man, almost every one must have perceived when looking back upon that past youth, never to return to us more.

In 1825 and 1826 he began making rude astronomical instruments for himself, and was a diligent student of the scientific literature of the day. Jamieson and Brewster's "Philosophical Journals" were eagerly devoured—nor was such a course of study destined to remain without fruit for long. In 1825 he entered college at the university of Edinburgh, and it is not a little curious that although Forbes from boyhood had been groping amidst the intricacies of physical science, he had done so—until August, 1825—without any knowledge of geometry, in which month we find him recording that he began Euclid. In the spring of 1826 we find him taking another decisive step—he then commenced an anonymous correspondence, unknown to all his friends, with the late Sir David Brewster. "On the 29th May, 1826," says he, "is recorded my first communication under the signature of Δ to Sir D. Brewster. It was a calculation of a conjunction of Jupiter and Venus on July 31st, but owing to an accident it was not printed." This interesting correspondence was continued for two years, and it was not interrupted by his journey to France and Italy in 1826. He visited Rome and Naples, and twice went to Vesuvius. We find him recording an eclipse of the sun at Naples, in November, 1826; and in December he went to the celebrated temple of Jupiter Serapis, subsequently so frequently a theme for the expatiation of geologists. His letters at this time are full of the eager picturesque descriptions of youth.

Among other places the home of Voltaire, at Ferney, was visited, and the few remarks he makes upon the occasion are not a little curious. "Went to Ferney," says he, "a beautiful drive of about a league (from Geneva); two rooms, as it is well known, are preserved as the philosopher Voltaire left them. I took little pleasure in seeing the recollections of this detestable man, of whom perhaps one may say, the sooner he is forgot it will be the better for his character and the peace of the world in general." On his return in 1827, he continued his correspondence with Brewster, having indeed sent several articles from abroad which duly appeared in the "Philosophical Journal."

On the reopening of the university session 1827-8, Forbes returned after his absence of one year, and re-entered as a student in the moral philosophy and natural history classes—the former class was then taught by Professor Wilson, and the latter by Dr. Jamieson. Of the vigour and fervour of the former the world has had ample opportunity of judging—the latter gentleman, however, was a complete contrast, being practical, prosaic, and accurate to a fault; and yet there was an affinity in the mind of Forbes with both—eminent as he was subsequently to be in natural science, he yet obtained the medal in Professor Wilson's class at the close of the session, and throughout life the professor and author remained the friend of Forbes. A heavy blow was

about to fall upon Forbes, his loving and indulgent father was suddenly taken from him, and in reference to this, his naturally religious disposition bears him up, and in solemn words he records in his diary his resolution to do his duty as a man towards God with steadfastness and truth, in the hope that he, too, might die the death of the righteous, having ever in view the fact of his being created for a future and eternal life. After a period devoted to seclusion we find him again resuming his studies at the university. In December, 1828, he boldly threw off the mask of Δ he had so long worn in his communications to Dr. Brewster, and avowed himself the author of the contributions he had from time to time forwarded to the "Philosophical Journal;" and Brewster acknowledged the communication of his real name with satisfaction, and shortly afterwards proposed Forbes as a member of the Royal Society of Edinburgh,—an honour not usually conferred upon a youth who had not as yet completed his twentieth year. Dr. Brewster introduced him in the following words, very marked in themselves:—

"Mr. Forbes has a family claim of an irresistible kind; but, even if he were the son of a peasant, his learning, his intuitive genius, and his absolute devotion to science entitle him to the warmest reception which the Royal Society can give him. He will be one of its greatest ornaments. I must also assure you that for years he has been an anonymous correspondent of mine, and that I promised solely from his talent to recommend him, when I did not know whether he was the son of Sir W. Forbes or of a peasant. He is also a travelled person, and has surveyed with a scientific eye the classical and volcanic wonders of Italy. If you can find men of his stamp you will do well to secure them."

This admission of Forbes into the Royal Society may be considered as his first recognition on the part of the public; and henceforward, to a certain extent, we may regard him in the light of a public man,—yet young, and yet to win those honours he so worthily wore—but at the same time it is a fitting period at which we may turn rather from the youthful philosopher in his personal capacity to that wider field of work in which he was to labour with results yet to be estimated by the scientific world at large. It is enough to say that his various branches of inquiry were followed up with his usual persistence. His diaries at this time are replete with observations of a mainly technical although useful character, but rather seem to illustrate the course of his studies than point at any decisive results of general utility. Diligence in observation is an especial merit to be noticed at this period of his life—a diligence which well deserved the subsequent distinction he achieved. In the course of 1830 he terminated his collegiate career, and as a fitting close to this section of his life we may well quote some remarks from his journal.

"Fettercairn, April 25th, 1830.

"The college session which has now passed, the last probably which I shall be seriously engaged in, has been less distinguished than the two preceding ones by much excitement. I attended Bell's lectures on 'Scot's Law' with extraordinarily little satisfaction, even less than I expected. Dr. Hope I reattended (along with John Buchanan) with renewed pleasure, and Leslie I also took another course of, though chiefly useful in directing my mind to problems I had not before studied. I easily carried off his prize, and, as I got a medal last year, I am going to have a copy of Newton's 'Principia' this time. I cannot look back upon my college education but with peculiar satisfaction, as comprising the happiest period of my life. Towards the University of Edinburgh, and the valuable friends I have acquired in several of its professors, I feel the warmest attachment. I would particularize especially Mr. Wilson and Mr. Jamieson; and as to Professor Leslie, he has been as kind to me, I believe, as his singular nature would permit; and I have had frequent though slight proofs of his good opinion. At the Royal Society I have been a regular attender, and made many scientific acquaintances. It was only on Monday last that I fully understood from Mr. Robinson that my recommendation as a member of the society was to be received as soon as I was twenty-one. He said:—'When are you going to be of age, to come among us?' I answered, 'To-morrow;' and it was agreed that the recommendation should be presented at the first meeting of next session, as that was the last of the past one."

When a young man of parts, of fair fortune, and of considerable power of thought, begins to take seriously to heart the question of a profession, he is apt to divide and subdivide his sensations until he ends by accepting nothing as a basis of action. In a very ingenuous letter to Lord Medwyn, his uncle, dated January 30th, 1830, he sets forth his difficulties. First he seems, like many more, to have leaned towards that singular haven for study, the church, as has already been written; next, in deference to his father's wish, he adopted what some deem the opposite profession—the service of this world's interests and squabbles—the bar. But here we again find hesitation. Stating his trouble in his own words, it seems to be thus:—"My distaste increased instead of diminishing. Indeed, I could not have tolerated such a struggle of mind, but in the hopes of, after a few years of drudgery, reaching a sheriffship, which, by adding £300 or £400 to my income, might enable me to pursue my darling studies at leisure. But my view now is that it is better to live upon little than to embitter the happiness of life by being more independent in fortune." It is partly from expressions such as these that the present writer is disposed to regard Forbes as possessing little real intellectual strength, such as he had being rather fine in quality than capable to encounter severe taskmasters in even his own favourite pursuits. Of course his case is very ingeniously argued. He alleges that mathematics have little charm for him, intuitively knowing that his intellectual strength was not equal to the strain demanded. His classical knowledge he frankly allows is inaccurate, although he admits the pleasure he experienced in the perusal of Latin authors. "You will ask," he continues, "what is to be done. I conceive, in the first place, I should pass advocate, and then either to prepare for the bar and race for a sheriffship, or to set-to with a vigour and entireness of application which to me is as a day dream, to qualify myself for a professor's chair. I should return unnumbered thanks to heaven on my knees could I engage in so unbroken, so delightful a career, even though the attainment of its end should be distant or uncertain." Clearly the tendency of his mind is here best expressed, and was fortunately the ultimate outcome of his life. Even Dr. Brewster, who must have felt how little mere "observations" and "calculations" are likely to advance a man in the world's esteem, was against his relinquishing the bar; and Forbes, in a letter to Mr. Colin Mackenzie, naively and honourably quoted the doctor's views thereupon, thus:—"I should like to see you measuring the boards of the Parliament house, taking what routine business came in the way, and thus fitting yourself for a sheriffship. During those two years you may devote two-thirds of your time to science, and then you might spend two years abroad acquiring the modern languages and carrying out your scientific pursuits." This was, however, distasteful to Forbes, who exclaims:—"In short, on my return home I was to find myself sheriff of Peeblesshire! much to the discomfort, I should think, of the county."

Sir David Brewster was a shrewd, true, and practical friend, and his discouragement was only to his honour. He tells his young and enthusiastic friend that he himself had written a treatise on optics as a youth before Forbes's age, the chief novelty of which was to consist in the practical portion, and that he afterwards congratulated himself on the fact that the work was never printed. A few sentences thus elicited from so able and kindly a man as Sir David Brewster deserve the widest circulation they can obtain among students of science. "A first work," he says, "clings to an author while he lives, and hence it is of great consequence that it be an original work, worthy of the status in science which he is destined to obtain. . . . I have no scruple in expressing my conviction that you are destined to do something important in science, and under this conviction I am confident that there is no object of ambition worthy of your pursuit but that of original discovery. My conviction is that the very first thing a scientific man regrets is that of writing a book at the beginning of his career, however good it might be; he sees how much better it would have been had he waited a few years."

This is admirable advice, worthy of the source whence it came. The dilemma was increasing; Forbes seemed more sadly to seek, and thought of following that profession in which there are so infinitesimally few prizes and so many blanks—that of a professional author. And even now, with very materially altered conditions, the general dissuasion to mere authorship holding true, even in the metropolis, what must the disadvantages have been in Edinburgh forty-three years ago?

Dr. Brewster again writes to him at this juncture of his life: "You threw out an idea in your first [letter] of wishing to remain a bachelor. This I cannot approve of. The married life is more appropriate to a man of science than to any other person; and though its unavoidable evils may sometimes interrupt the even tenour of a philosophical life, yet these evils, even in their worst form, are useful impediments in our lot, and are incalculably overbalanced, when considered only in their bitterness, by the hourly enjoyments of domestic happiness. But I would advise you not to expect too much happiness even from the fulfilment of all your wishes. The moment you have distinguished yourself you become an object of envy and malice; men whom you believed to be lovers of knowledge you will then find to be only lovers of fame, and haters of all knowledge that has not come from themselves. You will find that a life of science has in it no superiority to any other, unless it is pursued from a higher

principle than the mere ambition of notoriety; and that a demagogue or a philosopher differ only in the object of their selfishness. As you will now have experienced how unsatisfying even the pursuit of knowledge is when insulated from higher objects, I hope, if you have not been fortunate enough to begin the study earlier, that you will devote yourself to the most extraordinary of all subjects, one which infinitely surpasses the mechanism of the heavens or the chemistry of the material world—the revelation of your duty and the destiny of man as contained in the Bible—a book which occupied the best hours of the manhood of Newton, of Locke, and of Euler." Forbes's mind was now made up; friends and guardians alike were over-persuaded, though perhaps unconvinced, and in March, 1830, the strife was at an end. He was free, by the extorted consent of his responsible seniors, to follow the bent of his mind. "In June," he exclaims, "I hope I shall be free of law for ever. Then for self-cultivation! I mean to study the higher mathematics, and make some original researches connected with the fundamentals of meteorology. If things go well, I intend to go abroad the autumn of next year for eighteen months or two years. But I plan for the future with perfect diffidence. God only knows how far there may be between me and misfortune, disease, or death." In such a spirit, coupled with a reverent self-consecration to the path of life he proposed to follow, we find Forbes preparing for the future. This change in the general direction of his life was attended by an expatriation from Colinton, and thus everything was new and strange to the young and active-minded man. We cannot linger over his visits to London and Cambridge in 1831, but it is clear that the novelty must have done much towards enlarging his sphere of thought and rendering him happy in his newly chosen vocation. Perhaps the most momentous matter connected with this period is the establishment of the British Association for the Advancement of Science, an idea mainly attributable to the energy of Brewster, and in which his disciple Forbes took a deep interest. The writer of the present remarks saw Professor Forbes in 1865 at Birmingham, where he evinced the same interest in the objects of that scientific parliament that it is only right to suppose he did in the enthusiasm of his earliest scientific career. His connection with its establishment was fortunate for him, as it seemed an earnest of the dignified place science was about to take in British society, and, moreover, was akin to his wishes and hopes for the real advancement of philosophy. And it must be conceded that these scientific wanderings have lost none of their freshness for the real lover of knowledge, however changed some of the aspects of the Association have since become. Brewster, with characteristic unselfishness, rendered due justice to Forbes nineteen years afterwards, when, in addressing the association from the presidential chair at Edinburgh, he coupled the name of his favourite pupil with those of Sir John Robison and Professor Johnstone as among the earliest friends and promoters of that great annual gathering, since emulated in other branches of knowledge by other associative bodies. Professor Phillips, one of its earliest friends, remained, like Forbes, constant to its really noble objects. But Brewster himself—all honour to his noble name—was the chief promoter of this grand enterprise, in which the Reverend Vernon Harcourt undertook duties of the most delicate and harassing nature. The first meeting was held at the central city of York, where all vied with each other in consolidating this excellent work.

The professorial chair he had anticipated as being so far off was soon to be Forbes's; out of a number of candidates, including Dr. Ritchie, Mr. Thomas Galloway, Professor Stevelley, and last but not least his old and firm friend Dr., afterwards Sir, David Brewster, Forbes was elected to the vacant chair of Natural Philosophy at Edinburgh, previously filled by Sir John Leslie, on the 30th January, 1833, by twenty-seven votes to nine. In the manner accustomed to himself he again returns thanks to the Almighty for this great advancement at a time of life when such an honour was hardly to be anticipated. A prayer is given by his biographers, extending over two pages of their portly volume, which those may read if they should desire, but which it would be very inapposite to reproduce in this place. He was then twenty-four years of age, and such a distinction must have brought with it an extended sense of responsibility; in November he entered upon these new duties.

It is interesting to notice in what sense Forbes proposed to fulfil these new and onerous duties. He writes to Dr. Whewell in the following terms, which manifest his sense of what he was called upon to do:—"It is most urgently pressed upon me during my present laborious task of writing lectures, upon which I have been six weeks at work, that the difficulty lies, not so much in that of the subject, as in the very elementary manner in which it must be taught, the state of preparation here being low to a degree which, with your high academic notions, fostered by the spirit of your noble university, must appear almost incredible. From the moment of starting for the chair, I resolved that, should I be successful, I should make a sacrifice of my popularity, to an endeavour to raise the standard of science, and to rescue the noblest walks of learning from the exclusive dominion of the penny literature. In introducing into my lectures a cautious mixture of pure demonstration with experiment and collateral illustration, I have felt that all my labours are likely to be rendered useless for want of a fit text-book—I mean for theoretical mechanics. Notwithstanding the number of works on the subject, without, I hope, being fastidious, which my qualifications do not entitle me to be, I have found no work to my mind. In writing upon a subject so vitally important, I need not assure you that compliment is wholly foreign to my thoughts, when I state that your 'Mechanics' has appeared to me far the best book I have met with for teaching from, both from its admirable arrangement, which I have hitherto almost strictly followed in writing my lectures, its mixture of geometry and analysis, its subdivision into clear propositions and illustrations. But for my purpose it is too long: it is, on the whole, rather too difficult. What I want you to be prevailed upon to do is to publish a sort of abridgment of the work, requiring a grade less mathematics, and introducing into the dynamical part problems from your new introduction to dynamics, which, by the way, I mean to teach at a separate hour to more advanced students. I would have nothing further than the very elements of the calculus, and that part printed in a smaller type. . . Such a text-book as I want would be almost composed by the easy art of clipping from your own writings, and if you would add a short system of hydrodynamics—it would be an important addition."

To this proposition Whewell assented, and thus Forbes was enabled to inaugurate a higher tone both on the part of lecturer and students. He even took lessons in elocution from Mrs. Siddons, in order to add additional grace to the delivery of the arguments he proposed to employ in his lectures. Those who have heard him speak report most favourably on his winning and effective style, which he retained throughout his professorial career. His inaugural lecture, always a matter of great anxiety, passed off to the satisfaction and admiration of all his friends who crowded to hear him. During his vacations he travelled about England from place to place, not omitting to visit the place near Exeter where his long lost mother slept her last sleep, at Lympstone.

We have not space here to enlarge upon his professorial life—it is sufficient to say that it passed quietly by, and the intervals of his labours were devoted to a friendly and scientific correspondence with the galaxy of eminent men ornamenting the scientific firmament. Among these were Professor Powell, M. Quetelet, Professor (now Sir) G. B. Airy, Dr. Whewell, Sir John F. W. Herschell, Mr. Leslie Ellis, Professor Jamieson, M. Auguste De La Rive, M. Arago, Sir David Brewster, and many others.

That the students to whom his lectures were delivered thought well of their large-hearted preceptor is abundantly shown by the following address presented to him in 1836:—

"University of Edinburgh, February 16th, 1836.

"The students in the natural philosophy class in this university beg to convey their congratulations to Professor Forbes on the well merited honour which he received last night as the successful demonstrator of the polarization of heat. The students would express their attachment to Professor Forbes as to an excellent and amiable teacher, their personal interest in his scientific pursuits, and their personal pride in the successful results of these. That he has not only succeeded in displaying the polarization and depolarization of heat, but that he has also detected signs of its circular polarization, strongly excite their expectation that the evidence of interference will not long remain undetected by the delicate and judicious experimentalizing for which Professor Forbes is so justly celebrated. They hope to see the undulatory theory of heat as fully demonstrated as the undulatory theory of light, and Professor Forbes' name raised to the highest eminence among the philosophers of the day."

In November, 1841, he was elected secretary of the Royal Society of Edinburgh, a post he retained for a long time, and which he filled with his usual energy, until failing health obliged him to relinquish it. During the whole of this time his scientific activity underwent no relaxation, and he was engaged in perfecting that glacial theory, with which his name will ever remain associated. On the 4th July, 1843, he married Miss Alicia Wauchope, the eldest daughter of the late George Wauchope, Esquire.

We cannot resist transferring to our columns the admirable letter of Professor Sir G. B. Airy to Mrs. Forbes, in which the various scientific discoveries of Forbes are summarized in a most lucid way.

"Royal Observatory, Greenwich, London,
"April 11th, 1872.

"Dear Madam,

"When I last wrote to you I hoped to have a little time at command for bringing together some notes regarding my late friend, as soon as the short refreshment which I required should be terminated. But I have never had my thoughts free, and now I fear that the very few ideas that I can put together may be too late. I cannot say when or how my acquaintance with Mr. Forbes began. I have some obscure idea of having seen him before my marriage, which took place in March, 1830. But I certainly saw him at the meeting of the British Association in Oxford in 1832, on terms which implied acquaintance. In the latter part of that year he was candidate for a professorship —I believe the same which he subsequently obtained—and I had the pleasure of offering to him my certificate of competency. At the beginning of 1834, he was candidate for a different office; and I think that I then attempted to take a step in his favour as before. In the years from 1830 to 1835 I was much employed on physical optics in its two divisions of diffraction and polarization. Professor Forbes took great interest in these subjects, and I had much correspondence with him. I had arranged for my lectures at Cambridge a rather rude machine for showing the relation between plane-polarized light and circularly or elliptically-polarized light; and Professor Forbes entered heartily into this matter, and requested me to furnish him with a duplicate of my machine.

"The undulatory theory of light was then struggling into existence, or at least into reception; and the clear understanding and hearty support of it by Professor Forbes, must have contributed materially to its successful establishment in the locality with which he was more immediately connected.

"In 1835, the question was raised by me of the establishment at this Observatory of a system of continuous magnetic observations. I had from the first the advantage of frequent correspondence with Professor Forbes, on the various points entering into consideration. In 1836, Professor Forbes communicated to me as one of the first persons, I believe, his splendid discovery of the polarization of radiant heat. From this time, almost every important step made by myself, or in this Observatory, was made known to Professor Forbes; and almost every scientific enterprise undertaken by him, and his general proceedings at Edinburgh, were soon communicated to me. I forget in what year it was that I testified officially to the importance of the magnetic determinations which he had made with so much labour at different elevations above the sea. The record of his experiments on the conduction of heat through metal was lodged, at his request, in this Observatory.

"An early copy, I believe the first, of Professor Forbes's 'Travels in the Alps,' was presented by him to me; and I read with great interest the observations upon glaciers, especially the part beginning with the chapter which bears the appropriate motto,—

"'The glacier's cold and restless mass
Moves onward, day by day.'

"And I have often contrasted, in my mind, the well directed and careful observations there detailed, and the cautious deductions from them, with the paltry and doubtful objections that have been made to subordinate points of the theory. As a whole, this essay must hold a very high place. No person, perhaps, could testify better than myself to Professor Forbes's scientific character. In every investigation of his which I saw, he was careful, accurate, and truthful. He would not change an idea or a term for any consideration but his own conviction. This uprightness and manliness of character was impressed on all his transactions, and in time ensured to him the respect of all who had sufficient opportunity of witnessing it. It was matter of great pleasure to Mrs. Airy, as well as to myself, to enjoy the hospitality of your house, or to offer our own, to take part with him in an expedition for sight of a solar eclipse (1842), or in an excursion to our northernmost islands, or to put ourselves under his guidance in Scotland or in Savoy. In the systematic pursuit of science, and in preparations for accurate geography and topography, Professor Forbes prepared himself with powers which sometimes almost assumed the character of the lighter accomplishments. His mapping of the Mer de Glace of Chamouni is an excellent specimen of surveyor's work. In contemplation of an excursion, I found that he was taking regular lessons in drawing, and the fruit of these appeared in those most admirable depictions of Alpine scenery which adorn his book of travels in the Alps. I suppose that it may be asserted that the present popularity of Zermatt, a place which was before scarcely known, is almost entirely due to Professor Forbes' picture of the Matterhorn. The power thus obtained was of course used also for other purposes, and I know of at least one excellent sketch of scenery and antiquarian remains which still adorn a lady's portfolio. It is needless for me to say after this, how much the loss of my valued friend was felt by Mrs. Airy and myself."

Canon Kingsley, among others, testifies to the beauty of Professor Forbes' work on the glaciers. "We have heard Professor Forbes' book on glaciers," says he, "called an epic poem, and not without reason. But what gives that noble book its epic character is neither the glaciers, nor the laws of them; but the discovery of those laws, the methodic, truthful, valiant, patient battle between man and nature, his final victory, his wresting from her the secret which had been locked for ages in the ice caves of the Alps, guarded by cold and fatigue, danger and superstitious dread."

Slowly and surely the merit of Forbes grew into recognition, and in 1845 we find that great man and liberal patron of science, Sir Robert Peel, offering him a pension of £200 per annum, in recognition of the services he had rendered to science. This, with an increasing family and a decreasing state of health, was no doubt welcome. He observes on the occasion, "This will relieve me of much anxiety about my future prospects. I mean to reserve it principally as a store for old age, if I be spared to it, and at all events for the education and professional education of my children. By leaving my present income free to be used, I may pursue science with more liberty, and, if spared health, continue my travels. I trust I shall be delivered from the snare of a penurious and money-loving old age; but the night cometh, and professional men, especially professors, should retire ere they manifestly decline."

So with travelling and lecturing, experimentalizing and letter writing, we bring him up to 1849, in which year occurred his literary duel with the brilliant but fallacious essayist and historian Macaulay. The latter had, a little while before this time, visited Edinburgh for the special purpose of delivering an oration at the opening of a very large library and lecturing institution, and in the course of this speech he took occasion to ventilate one of those startling but not very profound paradoxes which his wit and eloquence could so epigrammatically point. He maintained that a little knowledge is not a dangerous thing, and that there is no line by which superficial knowledge can be separated from profound. He said that he never could prevail on any one of those persons who talk of the danger of shallow knowledge to admit what was their standard of profundity. "When we talk of deep and shallow, we are comparing human knowledge with the vast mass of truth that is capable of being known, and, tried by this standard, the most learned and profound are almost as shallow as the most ignorant. The sage of three centuries ago is not equal in knowledge to the child of to-day; the intellectual giants of one age become the intellectual pigmies of the next. Homer, and Plato, and Shakespeare, and Bacon must dwindle into insignificance as the world grows older. These views Macaulay sought to establish by pointing to the fact that any mechanic can now learn in a few days more about the celestial bodies from Herschel's astronomy, than the astronomer of the middle ages could learn in a lifetime; and Faraday taught the little boys and girls in his Christmas holiday lectures more chemistry than all the alchemists ever knew." Such brilliant sophistries as these were very distasteful to the conservative mind of Forbes, who boldly encountered them by two lectures, afterwards published in a small volume entitled, "The Danger of Superficial Knowledge."

Forbes first showed that the terms "great" and "little" are really unnecessary if used in relation either to the whole body of truth *per se*, or to the whole of what is cognizable by man. Knowledge can only be called great or little in reference to the mind receiving knowledge, and its capacity for so receiving it. Common sense is even offended by speaking absolutely of a little knowledge being a dangerous thing. If dangerous, it would be so to something sentient and capable of inquiry—to that human understanding receptive of the knowledge; and thus the effect might be expected to vary, not in proportion to the measure of the knowledge itself, but according to the capacity, the habits of thought, and the previous attainments of the recipient. And this is true, not only of individuals, but of different nations in the same age, and of the same nation in different ages. But if, instead of the term "a little knowledge," we talk of knowledge of a superficial character, gained suddenly and with little effort, such knowledge may truly be said to be dangerous. He illustrates it by saying that a legacy of £1,000 bequeathed to a poor labourer whose whole previous income was £30 a year, might very probably prove injurious, if not ruinous, to his habits and character; while to a man accustomed to spend £10,000 a year it would only be a small and useful addition. In fact, —and this is borne out by daily experience—power, wealth, or knowledge, when suddenly possessed by those unprepared to

employ them, become sources of real danger. Experience alone can convert such gifts into productive sources of good.

This kind of knowledge is called empirical, acquired by memory, but not attained by extensive study, comparison, and reflection. The man who thinks out a proposition for himself has a far better grip upon it than he who merely acquires it by a process of mnemonics. The difference actually lies in the mode of acquisition; and one of the most cherished fallacies of self-conceit consists in the confusion between the mental power, which originates great discoveries, and the far lower power required to understand and apply such discoveries when made.

To Forbes—as to any one else reflecting for a moment—it seemed inconceivable that any one would confound the state of mind of a person capable of originating the theory of gravitation and of composing the "Principia," with that of a reader of the same work, even supposing that every argument was cogently understood. Yet those who perceive no distinction between different sorts of knowledge, except in the nature of the fact, are prone to fall into such a confusion—omitting to remember that facts as such have no elements of magnitude in them. Their greatness consists solely in the ideas they suggest, the consequent powers they call forth, the light they shed, and the usefulness they generate. The individual mind, greatly acted upon by their force, alone deserve the merit, and is to be called great and noble. As Forbes lucidly says:—"A man may deduce truth entirely for himself, as Kepler did when he deduced the primary laws of the planetary motions, or he may be led to perceive and apprehend it as an act of his understanding, by receiving a mere indication or hint from another, as Galileo constructed a telescope from a hint of the toy of Jansens. Or he may extend and enlarge the knowledge which another has added to the common stock, as did the great mathematicians of the eighteenth century working upon Newton's theory of gravity. Or he may passively assent, as an intelligent reader, to the truth of what is set before him, as does every day the competent student of Euclid's Elements. Or finally, he may receive on trust the conclusions of another, without attempting to analyze the truth or comprehend the reasoning; and this last is the humble acquisition of many of the readers of popular science of our own time. All these are various ways in which the knowledge of the same facts may be attained by the understanding. It were childish to suppose that the effects of this knowledge could be the same, either in kind or degree, in all these cases, or on the character and habits of thought of the person acquiring it." Forbes then proceeds very sensibly to speak of the folly of disparaging the results of the great thinkers of former times because they were unacquainted with many facts and processes known to us at the present day. Indeed, it may be very well a matter of wonder that with the imperfect knowledge of old time so much was triumphantly established on so firm a basis that modern formulæ and processes merely corroborate the wonderful accuracy of ancient mathematicians and physiologists. In every department of human knowledge the main facts as accepted at the present moment remain undisturbed. Take, for instance, that triumph of ancient natural history—the History of Animals by Aristoteles. Scarcely a statement made in that work over two thousand years ago has been materially varied by subsequent discoveries in physiological science.

Macaulay had observed that "the knowledge of geography which entitled Strabo to be called the Prince of Geographers, would now be considered mere shallowness on the part of a girl at a boarding school." This Forbes emphatically denies:—"It was," he says, "a profound knowledge of geography, and it produced the effects of profound and well-directed knowledge ever increasing, yet ever tempered by the conviction of ignorance; a knowledge which taught his contemporaries to enlarge their acquaintance with the common family of man, to extend commerce, and to preserve human life. Whereas the knowledge of the boarding-school, unless it be tempered with more humility than can be possibly looked for whilst such comparisons are uttered by men of talent on such occasions, will begin in ostentatious displays of memory, and end in pedantry and conceit."

Strabo was, however, not the only instance Forbes might have cited. Our increasing knowledge of the geography of Africa at the present day, thanks to Burton, Baker, Livingstone, and many others, has proved that Ptolemy, the geographer and astronomer, was far more correct in his assumptions, or that his knowledge was far more accurate than was suspected; the same observation holds good of Herodotus, whilome the father of lies, but now truly regarded as the father of history. Dr. Maitland many years since vindicated the dark ages, as they were called, from being so very dark, and it certainly seems an imputation upon antiquity of a most undeserved character to stigmatize the writers of that time with wilful misrepresentation. Men had eyes to see and pens to record what they beheld, and in the very last few months we have seen suspected and fragmentary historians verified by the actual translations of contemporary documents, the key of which has been discovered by modern philologists. Sanchoniathon, Berosus, and others resume their place as trustworthy guides to a portion of that ancient history which was lost or distorted by the lapse of time.

With reference to the practical use to which a "little knowledge" is sometimes applied, Forbes very happily says:—"The empiric who has acquired a sort of sleight-of-hand acquaintance with a parcel of facts, and uses them ingeniously, may outshine for a time the more profound and practical student, and the latter may even be unable to cope with him in his own narrow field of display. But for the production of fresh knowledge, or substantial additions to the capital of the human mind, our superficial aspirant is incapacitated by the very habits which have gained him a popular reputation. We have it on the authority of Newton himself, that if he was in any way superior to other men, it was in the faculty of patient and concentrated thought. 'I keep the subject constantly before me,' he said, 'and wait till the first dawning opens slowly, by little and little, into a clear light;' a sentence which speaks to the experience of all who have accustomed themselves to habits of patient study. But the superficial thinker has no such dawn. Facts are things which admit of no degrees. He knows them, or he does not. He is in a blaze of what he calls light, or else he is in total darkness. He evidently never thought in the way that Newton thought; his knowledge, if knowledge it be, comes to him through some different avenue. Facts are not knowledge, any more than books possess understanding."

By such sober arguments Forbes met the brilliant paradox of Macaulay; and there can be little doubt that a perusal of what he says will do much to check that fatal and facile faculty of theorizing with which the arrogance of youth is so frequently cursed. They are wise words to be laid to the heart and remembered in the brain among all students who desire to excel in their several branches of study. Certain modes of avoiding the fascination of superficial knowledge are added, such as the recommendation that every acquisition of knowledge should not be made an isolated effort, but a portion of the entire mental discipline; that facts should not be rested in, but the laws and generalizations by which they are connected should be grasped at, the ideas and theories binding them together should be appropriated and formed into a body of science; a habit of combining study with reflection should be encouraged, so as to make the mind something more than a mere machine.

Thus, in noble incitement to study, in unwearied efforts towards self-improvement, the life of Forbes passed away, the charms of home surrounding him and soothing his hours of leisure; and as the time came round he escaped to the Alps of Savoy or the Fjords of Norway, bent upon widening his basis of observation and adding more and more to that knowledge in which his soul and mind delighted.

For the record of his numerous scientific journeys it will be better to refer the reader to the memoir from which we draw the materials for this article; to give any extended account of them would considerably weary the reader, and a skeleton sketch would be equally unprofitable. His own lively words will best content those who wish to follow him in his wanderings. We will therefore pass on to a few more circumstances of his personal history. In the latter part of 1851 his health began to fail, hæmorrhage seized him on the 30th of November, and by the 2nd of December his illness assumed a more serious aspect, and during that month he lay between life and death, and by January he was removed from Edinburgh to the milder air of Clifton near Bristol, his head-quarters for the next two years. But he still continued to labour in some way; articles on science for the "Encyclopædia Britannica" were produced by him, and he was also preparing for the press a work on Norway and its glaciers. In the summer of 1853 he was called to Oxford to receive the degree of D.C.L., at the commemoration at which the late Earl of Derby was installed Chancellor of that university. In June, 1854, he returned to Edinburgh, and actually resumed his place in the lecture-room for three days a week; and so matters proceeded during 1855-6, with occasional excursions among his friends. In November, 1856, his dissertation on science in the "Encyclopædia"—the work of four years—was finished, printed, and as he gleefully writes to his friend and physician, Dr. Symonds, "paid for." He received £420 for the copyright of this admirable treatise. His health was partially restored at this time, although it was plain that the remainder of his life would be mostly spent as an invalid.

The foundation of the Alpine Club in 1858 Forbes hailed with delight, as it promised to carry on the work he had commenced, and his name appeared at the head of the list of honorary members. The members of this enterprising body were, however, rather bent

upon doughty feats of climbing than mere scientific research, "unbounded muscular exertion and unfettered freedom of range." Still such advice as he imparted was ever eagerly and gladly accepted. In one of his letters to one of his Alpine correspondents he says: "I congratulate you on having so sincere a taste for mountain scenery; and as your acquaintance with it and with physical geography increases, I trust that you will be able to make further and still more valuable observations, for there is still much to be done with the glaciers, as well as other subjects. The state of my own health prevents my renewing my active explorations; but it is a very great pleasure to me to hear from you and others of the prosecution of Alpine research; and if my advice can be at any time and in any degree useful, it is much at your service. Robust I can never again expect to be. The mountains are for you and your cotemporaries."

The autumn of 1859 saw an important change in the life of Forbes. The Principalship of the United College in the University of St. Andrew's became vacant by the transference of Sir David Brewster from that post, which he had held for more than twenty years, to the Principalship of the University of Edinburgh. For this post Forbes became a candidate, and it is honourable to all political parties to record that he received support from ministers of every shade of politics, including Sir G. Cornewall Lewis, the Duke of Argyll, and Mr. Gladstone. He was speedily elected, and took his official position on the 10th December, 1859, holding his professorship until 1st of April, 1860; on the 10th he delivered his last lecture, and on the 16th received from Edinburgh the degree of LL.D., in company with Mr. Gladstone, Dean Mansel, Dean Ramsay, and other distinguished men. His farewell address to the graduates of arts was delivered on the 25th April, in which he bade farewell to that university with which he had been so long and beneficially associated.

The time at which Forbes entered upon his new duties at St. Andrew's was one of great moment for that university. The Scottish University Commissioners were in full session, busily forming ordinances which should control the course of study, the university finances, the library privileges, and the professors' salaries for a long time to come. It was Forbes's duty to supply the commissioners with the information they required. The finances of his own college were in a wretched condition, and to understand these and devise means for their restoration was the first task to which he addressed himself. He greatly aided the commissioners in extricating matters from the entangled state in which he found them, and set matters on a footing likely materially to benefit professors of the next generation. The university chest and its contents had next to be examined, and this part of the task was far more satisfactory. The flourishing condition of the exchequer was owing, however, to the source derived from the granting of medical degrees, a point on which it was known the commissioners had decided objections, although it would seem that the examinations had been conducted under Drs. Reid and Day in the most unexceptional manner. The right of granting degrees was finally settled to remain, under very considerable restrictions.

A third project, which soon engaged the attention of the new principal, was the founding of a college hall. At St. Andrew's, as in the other Scottish universities, it had been customary for students to live where they chose in lodgings in the town, regularly attending the professors' lectures, and maintaining good conduct. But a college-hall appeared a want of the times, and Forbes threw himself into the project of creating one, with the usual energy of his character. Within two years of the time of his appointment this was accomplished, and subsequently large buildings for the accommodation of students have been erected. The restoration of the college chapel of St. Salvator's was another of Forbes's favourite ideas; and in this, by diligence and suavity of manner, he also succeeded, but not without an appeal to the Court of Session. In the interval of these duties Forbes from time to time lectured to the students on subjects which had long been familiar to him, such as "Glaciers," "Climate," "The History of Discovery." These lectures, however, were more numerously attended by the townsfolk than by the students—perhaps they were not regarded as in the regular curriculum of study. Youth is not over anxious in these days to do more than just satisfy university requirements; and it is to be deplored that this spirit of doing just enough and no more is rather on the increase everywhere than on the decrease, despite our flourishing English and Scottish university reports. This, however, is not the place or the occasion to discuss such a subject. The new college-hall perhaps will remain as the best memorial of Forbes's activity at the University of St. Andrew's. His last appearance in public life was in 1867, when he attended the ceremony of laying the foundation-stone of that building, performed by Mr. Whyte Melville, as Grand Master of Freemasons. Forbes then delivered an elaborate address, detailing the objects of the building they were met to found, the brief history of the institution, and his hopes regarding it in the future.

In May, 1867, his cough continuing unabated, he still was found active, making a journey to London, and two journeys to and from Cambridge; and finally in the autumn, by the advice of his physicians, he set out for Cannes, in the south of France, accompanied by Mrs. Forbes and his three daughters, but he soon left for Hyères, where the air was softer. In April, 1868, fearing the heats of Hyères, he again, amidst racking pain, set out for English ground, and arrived, in a state of the utmost prostration, at Clifton, in May. He was then desirous of resigning the Principalship of St. Andrew's, but did not do so until October of the same year, requesting that the resignation should take effect on the 15th November of that year. He gradually sank under his complaint, being intelligent and conscious to the last; and after an affectionate farewell to all those who owed to him their being, he passed away into the hands of his Creator on the 31st of December, 1868, mourned with the utmost sincerity by all those who admired his consistent and noble life.

His character is ably summed up by his biographer in the following words:—"Religion and science in him were so far independent that he never troubled himself to build a bridge of reconciliation between them, such as are so common now-a-days. Still less did it ever occur to him to import into religion those physical modes of thought now so much in vogue. I think I can see the look of grave contempt with which he would have regarded any one who proposed to trace the origin of all things to the working of a blind, soulless force, rather than to the ordering of a loving and All-wise Mind. With Faraday, he believed that no man, by reasoning or science, can find out God; and if any tried to do so, they would have got little help from Forbes. But in him they would have seen one well acquainted with all that modern science has really made good, and with all the methods by which it works: one who had himself added real contributions to scientific discovery, and who looked forward hopefully to far greater things yet to be discovered, and the great Christian verities as the anchor of his hope: and this in no dim, struggling way, but with the most practical and ennobling faith. The outward form in which these truths came home to him was that in which they are presented by the Church of England Liturgy. This he was content unhesitatingly to accept. He never sought to rationalize it, and had small sympathy with those who did.

"About his religious convictions he never argued, but acted on them silently and consistently. In this way, while his own mind was not disquieted, others took note of him, and received more good from the silent transpiration of his character than they could have got from any arguments. There were those associated with him at different periods of his life who owed to his strong but unobtrusive faith the deepest and most lasting effects on their own character; and that faith which had guided himself and influenced others in the days of his activity did not fail when the great trials of life fell upon him. During the long shadows of declining life, as earth with its interests receded, the things unseen came closer to him, and continued to be his strength and consolation to the end."

We have now in conclusion to examine briefly the scientific work done by James David Forbes. His name has been chiefly associated with a particular theory of glaciers, a subject of more importance to abstract geognosists than to the practical scientific man. As nature cannot be altered to suit the actual convenience of mankind, a theory of glaciers, however well founded, can be of little utility. It scarcely belongs to *dilettante* science, but it verges on that which can never greatly affect the prosperity of nations, and in this sense belongs to the realm of speculative natural philosophy. As an illustration of the eternal activity of Nature, it unquestionably has an influence upon such minds, full of religious awe and love for the untiring Creative Hand; and that a mind so imbued with a true sense of the love of the Creator for that which He had created should reverently and carefully attempt a solution of such a problem, is far from unnatural. Here for Forbes the awful power of the Great Architect of the Universal Frame was so manifest that his mind became instinct with a desire to discover as much as might be revealed, through Nature's book, of the intentions guiding the Creator in placing this great chain of icy mountains in the midst of a great continent. The fertile valleys of the Alps are the answer in practice. Those who, like the writer of these lines, have visited these awful solitudes, cannot but be impressed with the necessity for such an arrangement. But there the whole question comes to an end—that a great chain of mountains on the verge of a sultry climate should exist to moderate it, is enough for all actual purposes. We have not here to discuss the political significance of this great barrier, but it is certainly true, that without these impassable solitudes, in times past, when man was not sufficiently elevated in intellect to thoroughly love art and beauty for its own sake, many, if not all, of the trophies of ancient times might have been swept away. But the

consideration of glaciers in themselves, it would scarcely seem, would ever lead to anything further. They form, however, in themselves, a practical confutation to those who assert that the Creator has deserted the planet on which His infinite wisdom has spent such pains. To the religious man, not the mere observer of ritual, such chains of mountains form a constant source of faithful reverent observation and gratitude. It may be that it was rather a feeling of this kind that attracted Forbes to the mysterious Alpine chasms, and brought him more directly within the sphere of natural religion as taught by God Himself, than all the petty experiments of the laboratory, however delicately conducted, could have brought him. There is a fascination in mountains felt by races and individuals; poets have sung of them, and patriots have lived among them, hermits have sought refuge, from meaner inspiration, among them, while politicians and mere worldly men have looked upon them in the light of physical obstacles in the way of their schemes and their convenience. We shall, however, rather turn to the other works of science which we owe to Forbes.

His remarkable "Dissertation on the Progress of Mathematical and Physical Science, principally from 1775 to 1850," was published in the last edition of the "Encyclopædia Britannica." Its nature is chiefly historical, and was successfully accomplished, evincing great reading and deep knowledge of the subject, with a calm, unbiassed judgment in execution. This work, which he himself regarded as his most important contribution to scientific literature, will always repay the study of any one really anxious to master the history and progress of modern science; in that sense it becomes a text-book of a most important kind.

In a strictly scientific sense, however, the most original subject which ever engaged the attention of Forbes, at a time when his mental activity was at the highest, was with reference to the polarization of heat. This is unquestionably the best of his discoveries, and we cannot give a better account of it than in his own words. He says: "I have just referred to my own early experiments on the subject (which were likewise inconclusive), in order to explain that it was natural, on hearing of the application of the thermo-multiplier to measure radiant heat, that I should wish to repeat them with the new instrument. This I did in 1834. I first succeeded in proving the polarization of heat by tourmaline, which Melloni had announced did not take place; next, by transmission through a bundle of very thin mica plates, inclined to the transmitted ray; and afterwards by reflection from the multiplied surfaces of a pile of thin mica plates placed at the polarizing angle. I next succeeded in showing that polarized heat is subject to the same modifications which doubly-refracting crystalline bodies impress upon light, by suffering a beam of heat, even when quite obscure, after being polarized by transmission, to pass through a depolarizing plate of mica, the heat traversing a second mica bundle before it was received on the pile. As the plate of mica used for depolarization was made to rotate in its own plane, the amount of heat shown by the galvanometer was found to fluctuate just as the amount of light received by the eye under similar circumstances would have done. This experiment, which, with the others just mentioned, was soon repeated and confirmed by other observers, still remains the only one proving the double refraction of heat unaccompanied by light, and though somewhat indirect, it will hardly be regarded by competent judges as otherwise than conclusive. Iceland spar, and other doubly-refracting substances, absorb invisible heat too rapidly to be used for effecting *directly* the separation of the rays, which require a very considerable thickness of the crystal. I also succeeded in repeating Fresnel's experiment of producing circular polarization by two internal reflections. The substance used was, of course, rock-salt." As Mr. Tait remarks, "Taken in conjunction with the experiments of Melloni and others, on the absorption, &c., of radiant heat, this splendid series of researches forms the conclusive proof of the *identity* of thermal and luminous radiations—a fact of the very greatest consequence to the further progress of one of the most fascinating branches of physical science."

Forbes also contributed to science by his researches on the conduction of heat by iron bars, and his quantitative measurements of the conductivity of iron at various temperatures. In 1833 he had called attention to the fact that the order of metals as regards thermal conductivity is the same as that for electric conductivity. The grand result of this was to show that, in iron at least, increase of temperature diminishes the thermal conductivity, as it had long been known to diminish the electric conductivity, and, curiously enough, in somewhat of the same proportion. He also first determined the absolute conductivity of a metal, *i. e.* how much heat passes through an iron plate of given thickness per second per unit of surface, the faces of the plates being maintained at constant given temperatures. Another favourite subject of Forbes was that of underground temperatures. This is still being carried out near Edinburgh by sets of thermometers buried in totally different surface materials. In looking over the list printed at the end of this volume of the numerous contributions made by Forbes to the scientific literature of his day, we cannot but be struck with the singular fidelity he observed towards his goddess Science, and how very little, if at all, he strayed from the precincts of her temple. But the main interest we, as his successors, can feel in James David Forbes, is the fact that he was an eloquent, strict, single-hearted teacher of science, honourable and scrupulous to a degree, unbiassed by fear or favour, and anxious above all for the truth as attainable by scientific processes, and zealous for that other verity which comes to us in the form of a revealed volume forming the basis of that religion in which he unobtrusively lived and died, the Church of England. He was a man of whom Scotland, amidst its crowd of great men, may well be proud, for to the careful training of a numerous section of present society he devoted without stint the best years of a lifetime. To him both the University of Edinburgh and that of St. Andrew's owe a great debt of gratitude, for he everywhere appears to have raised the tone of those about him. His classes are still enthusiastically spoken of by his pupils, and his cautious reforms, only made to rehabilitate and adorn the cause for which he laboured—national enlightenment—will remain as trophies to the memory of this noble son of science.

K. R. H. M.

THE FERRARA MARSHES.

ON the shores of the Adriatic, and lying between the two principal estuaries of the river Po, is a vast tract of marshy land, which is too wet to admit of cultivation, and which diffuses its unhealthy exhalations over the surrounding districts. This tract, known as Ferrara Marshes, extends over an area of nearly 200 square miles, and, thanks to the enterprising spirit of the age, this unprofitable and malignant district is about to be reclaimed and utilized for agricultural purposes. The work of draining this vast morass, which is in part submerged, has been undertaken by an Anglo-Italian Company, the joint engineers being Mr. James Longridge and M. Bella. The estimated cost of the operations is about half a million sterling. A few large drains and canals already exist in the district, and the Po-di-Goro protects it from the sea. Other canals, however, are to be made which will all converge to Codogoro, on the southern or Ravenna border of the tract, at which point is the main pumping station, now in course of erection. The drainage waters will there be discharged into the Volano—one of the ancient courses of the Po—through which they will find their way into the Adriatic. Should a dry season occur, a very simple means of irrigation will be resorted to. The deposits made by the river Po are constantly tending to raise the level of its waters, and necessitate a corresponding increase in the height of its banks. To such an extent has this been carried on that at Ferrara the river is actually on a level with the house-tops. Hence, by means of syphons, it will be a very easy matter to irrigate the country, should the necessity ever arise.

In carrying out this important reclamation scheme the largest and most powerful set of centrifugal pumping machinery yet constructed will be employed. The centrifugal principle was adopted by the engineers of the works after mature consideration, and not before they had visited Holland and other countries where draining on a large scale is practised. The pumping machinery has been designed and manufactured by Messrs. J. and H. Gwynne, of Hammersmith, and consists of eight pumps disposed in four pairs, each pair being driven by a pair of compound engines placed between the two, and being independent of the others. The bed-plate for each set of pumps and engines is of cast-iron, made in three parts, weighing 20 tons, the sections being bolted together so as to form a solid mass. The shafts of the pumps are prolongations of the crank shaft of the engines, the connections being made by disc couplings, on which are keyed small disc fly-wheels containing the balance weights. One of these wheels in each set is a worm wheel, and is fitted with turning gear, so that the pumps can be started by hand if necessary. The casings of the pumps are each 15 ft. in diameter, and have been successfully cast in one piece. The discs of the pumps are 5 ft. in diameter, and the suction and delivery pipes 4 ft. 6 in. The pumps are so designed as to afford every facility for internal examination, neither the pump-casing nor any of the pipes, except the outer suction

branch, having to be disturbed for that purpose. Each pair of engines, which are on the compound principle, has a high-pressure cylinder 27½ in., and a low-pressure cylinder 46⅝ in. in diameter, with a 2 ft. 3 in. stroke. The two cylinders, together with the valve chests and the intermediate receiver, are cast in one piece, a special machine having been designed for boring them simultaneously and perfectly true. Surface condensers are used, the tubes of which are traversed by the water discharged by the pumps, and are thus rendered very effective. Steam will be supplied to the engines from two groups of boilers, which will be located in two houses, one at each end of the engine-house. There are five boilers in each group, each boiler having two furnace flues leading into a combustion chamber, which is intersected by Galloway tubes. From the far side of the combustion chamber a set of 108 tubes, 3 in. in diameter by 4 ft. long, extend to the back of the boiler. Each boiler has 30 square feet of grate area and 730 square feet of heating surface; the working pressure of steam will be 70 lb. per square inch. The engines represent in the aggregate 2,000 horse-power, and their working speed will be 115 revolutions per minute. The total weight of metal in the four pairs of pumps and engines alone is about 450 tons.

It may be supposed that such ponderous machinery as this will have some heavy work to do. When working at the mean lift of 7 ft. 3 in. (the *maximum* lift is 12 ft.) each of the eight pumps will discharge 57,000 gallons of water per minute. The total discharge from the set will therefore be 456,600, or nearly half a million gallons per minute; or, to carry the calculation a step further, 656,640,000 gallons per day of 24 hours. In order to afford some idea of what this quantity of water really means, it may be mentioned that according to a recent return the total quantity of water supplied by the whole of the London water-works is somewhat less than 110,000,000 gallons per day. It will thus be seen that the quantity of water lifted daily by the Ferrara pumping machinery is six times that of the whole metropolitan water supply. The manufacture of the machinery was commenced by Messrs. Gwynne in January, 1873, and the first set of pumps, with their appurtenances, was completed in July last. The finishing stroke has just been given to the last set, and a recent inspection of them at Messrs. Gwynne's works leads to the conclusion that both design and manufacture will enhance the merit of the apparatus, which collectively constitutes the largest set of pumping machinery in the world.

THE DANUBE CANAL AT VIENNA.[1]

EVERY winter, when the first ice is seen coming down on the canalized Danube branch which runs between the Inner Town and the suburbs of Leopoldstadt and Brigittenau, that portion of the population of Vienna who dwell on the low grounds along that line are seized with an instinctive feeling of uneasiness, which may be heightened or lessened according to circumstances, but which never entirely leaves them until they have seen the last morsel of ice float down and disappear. The uneasiness felt on their part is natural enough, for that ice represents the constant danger of inundation. The intricacy of the Danube branches just about and below Vienna makes them more liable to be icebound, large masses of ice being heaped up on one another at the more exposed points, while from the same cause, in spring, the ice which has been formed above where the river is united is likely to move earlier and press down on the mass standing below, heaping up the waters, which threaten to overtop the dykes constructed to ward them off. High as the dykes appear to you in ordinary times, you see the distance between them and the water diminish on such occasions with alarming rapidity. There is scarcely any necessity for consulting the official table of variations; you see the water rise before your eyes. Every one is on the alert; and the Special Commission of the town, which is appointed every winter for the purpose of watching the river and taking all precautions in case of inundation, sits *en permanence*, for from moment to moment there is no saying what may happen. If you walk through the parts of the town most threatened you see boats and ladders arranged, and all the preparations made for erecting stages, over which the people may, in case of inundation, betake themselves to the higher parts of the town; and in some of the lowest portions of the suburbs this necessity arises, on an average, every third year.

It was even more with a view to guard against these chronic inundations than with that of making Vienna a great *entrepôt* on the Danube that the grand works for regulating the river have been undertaken, by which the numerous intricate branches are to be cut through and united into one stream. To do this effectually it would have been necessary to close likewise the canalized branch of the river which runs between the Inner Town and its northern suburbs; but this branch is, at least for the moment, a most important channel of communication, as any one can easily convince himself if he go along the banks of the Danube Canal to Nussdorf, where it branches off from the main stream. Right and left you see little else but establishments, manufactories, and storehouses, which are more or less dependent on the trade with the Upper Danube. All the ships which are used for the transport are built so as to suit the Danube Canal, and bring or take their wares from the doors of these establishments. All this may possibly, and indeed is very likely to, change when once the new Danube Town projected along the regulated main stream is built up and become the port of Vienna on the Danube; but for the moment this town of the future does not exist, so that, by shutting up entirely the Danube Canal, though, perhaps, technically it might be quite possible, the town would not only be deprived of one of its most salient features, but likewise of a necessary artery of communication before another could be substituted for it.

Some way had therefore to be found, in connection with the regulation of the river, for maintaining and, if possible, improving this existing channel of communication, and also for guarding against the dangers which arise almost every winter from this water-way through the town. In fact, these dangers were greater almost than those to which Vienna was subject from the intricate winding course of the main stream close to its gates. The head of the canal at Nussdorf, where it branches off, faces the river in a more direct line than the main stream, which makes a bend just there to the north. This is an advantage in summer, when water is wanted to feed the canal, but it is a danger in winter, for with the water the floating ice also has a tendency to get into the canal. At the mouth of the canal, on the contrary, the canal joins the main stream, at an angle which would make the discharge of the ice under all circumstances rather difficult, and this makes the discharge of the disproportionate mass of ice which floats in from above doubly difficult. Sometimes, as two years ago, it was quite a sight to see the gigantic masses of ice, which got heaped up and were pushed out on the fields right and left, forming icebergs.

To prevent this, but little could be done at the mouth of the canal. Even if the angle was ever so much diminished, the volume of ice in the main stream and the pressure consequent upon it were so superior to the ice and pressure in the canal, that the ice in the canal had little chance of forcing its way through the densely packed mass in the main stream. The only way which therefore remained was to make some arrangement to prevent the ice from the main stream above getting into the canal, which would have to discharge the ice formed in its own bed. Many were the discussions and consultations of engineers as to how this could be done most effectually, and at last the project of Hofrath Engerth, the chief engineering authority in the Danube Regulation works, was adopted. His machinery consists of an iron floating caisson, which may be sunk or raised *ad libitum*, and which is placed between two massive piers of granite constructed about 200 yards below the entrance of the water into the canal. Between the fixed piers and the caissons there are moving buttresses of iron, by means of which the movements of the caissons can be regulated. The caisson, which is 150 Vienna feet in length and 18 in width, is pointed at both ends, so as to bear the pressure of the ice and water more easily. It is made of strong girders, and weighs 35 tons. The inside is built in compartments, strengthened by transverse girders. There is a middle compartment of 60 feet length by 5 feet high, which can be filled with water to sink the caisson 6½ feet deep. The other two compartments may likewise be filled with water by means of vents in the bottom. A steam-pump, fixed on the deck of the caisson, serves to relieve it of the water and raise it if required. The construction of the caisson took a year. It was finished in the shipyard in Linz, and brought down in the course of the summer, when it was anchored in the main stream, where it formed one of the objects of the Exhibition. The preparation of the place where it was to lie took scarcely less time, for it was necessary not only to build the piers themselves, but likewise to strengthen and rivet with stone the spur which separates the canal from the main stream, since that will have to bear no small portion of the strain. It was, indeed, these preparations which delayed the application of this device so that it could only be made yesterday.

[1] From the Austrian Correspondent of "The Times."—Vienna.

It was high time, for the ice is already floating down the stream, and, what with this and the intense cold which had frozen the ropes and tackle, the mooring of the caisson to its place was no easy work. The work was begun the day before, and it took an hour and a half alone to turn the caisson. A large number of people from the neighbourhood as well as from the town had come to assist at a work in which so many were interested and which will serve as the test of a new hydraulic invention.

Whether it will answer and will protect the most threatened districts of Vienna from inundation remains to be seen. From all appearances, the new invention is likely to be put to a severe test this winter, for the winter promises to be a severe one. We have had already 15 deg. Fahrenheit in the town and outside a good deal more. This is but a foretaste of winter, its real strength showing itself usually in January and February. With the new device at the entrance of the Danube Canal, people may sleep more quietly now, although it would not be wise to feel too safe for all that. Even if the caisson answers, the question is, how the closing up of one channel for the ice and water will affect the others. Even when that channel was open, the water often rose in the main river so as to overtop the dykes and help to flood portions of the town between the canal and the main stream, and this is more likely to be the case now that the canal has been shut up. The completion of the whole work of Regulation can alone give perfect security, and this will be effected about the end of next year. Although the work has considerably advanced in all the three sections into which it is divided, the banks which separate them stand there still, and over that separating the two lowest sections there runs still the old northerly high road from Vienna, crossing over the wooden bridge. The present main stream is to disappear after the new bed has been opened in all its length. But side by side you see the piers of the new iron bridge, which may be completed by next summer, when the excavator can be set to work to remove the tongue of land which separates the two sections. Then only can the Vienna population sleep quietly in winter and spring, without fear of being awoke by the rush of water.

ON SOIL ANALYSES AND THEIR UTILITY.

(*Abstract of a Paper read at the Dubuque Meeting of the American Association for the Advancement of Science, by* EUGENE W. HILGARD, *State Geologist of Mississippi.*)

IN this paper the author reviews the objections against the utility of soil analyses, as set forth by Professor S. W. Johnson, of Yale, in an article published in the "American Journal of Science" for September, 1861. He states that, while agreeing with Professor Johnson in many of his strictures, he thought some of the objections urged inapplicable to large classes of soils in the South and West, while others were avoidable. With this view he had continued, or caused to be continued, the analytical researches already carried on for some time on the soils of the state of Mississippi. From the results obtained in the analyses of over 200 soils and subsoils, he concludes that highly important practical information can be derived from series of analyses, carried out upon a uniform plan, upon soils directly derived from uniform or uniformly variable formations, as is the case to a great extent in the South and West. The cardinal objection, that representative specimens cannot be obtained, however weighty in mountainous districts and on manured soils, becomes untenable on the prairies and even in the rolling uplands of the South, provided due care is exercised in sampling the soil—an operation second in difficulty only to the analysis itself, and not to be trusted to inexperienced hands.

For the purposes of soil analysis no commercial re-agents can be used, since however pure they may have been when originally prepared, the acids, ammonia, &c., become contaminated when kept in glass bottles for a length of time. All liquid re-agents used must be specially prepared in small quantities as required. The solvent to be used should not go as deep as H F, or fusion with alkaline earths; nor fall so far short of what the rootlets of plants can perform in the way of solution as carbonic acid. Hydrochloric acid of uniform strength, sp. gr. 1·11 to 1·12, as obtained by steam distillation, was used in all analyses for a uniform length of time, and all operations were performed in as uniform a manner as the variety of materials permitted.

We can thus obtain *comparative* and *comparable* data, giving not the entire amounts of nutritive soil ingredients present, but the amounts respectively accessible to the action of one and the same degree of solvent action, supposing, of course, the nature of the materials to be substantially the same. We can thus compare, not any two soils from distant localities, but series of soils of essentially similar origin.

The object being, not an exhaustive determination of *all* the physical and chemical characters of the soil, but something practically analogous to the assay of ores, the chemist should on the one hand be relieved from the numerical determination of such factors as can, with sufficient correctness, be estimated comparatively, while on the other hand he should avail himself, in the practical interpretation of his results, of all that an accurate study in the field, coupled with whatever experience may have been acquired by cultivators, can afford in the way of facts and suggestions. Mere columns of figures can be of little value, except as showing a great excess or scarcity of some important ingredient.

Of the latter, *potash*, *phosphoric acid* and *lime* are those whose presence in greater or less quantity chiefly determine the chemical value and character of the soil; vegetable matter or "humus" must also be accurately determined, since upon it, as well as upon the clay present, chiefly depends the important absorptive power both for ammonia and moisture.

The results of silt-analysis being as inadequate to determine that factor as is the chemical composition, the direct determination of the absorbing power for aqueous vapour has been studied, with this result: that for the ordinary range of temperature in a saturated atmosphere, the co-efficient of absorption is sensibly constant for one and the same soil, being for—

Very sandy soils . . .	1·5 to 2·0 per cent.
Loam soils	5·0 to 8·0 „
Heavy clay soils . . .	12·0 to 15·0 „

these numbers representing with tolerable accuracy what is practically expressed by "heaviness" and "lightness;" large amounts of humus and ferric oxide, however, interfere occasionally with the practical correctness of the estimate so formed.

The author's conclusions may be summed up thus:

1. While the analysis of *cultivated and manured* soils can seldom give us information of much practical value, from the difficulty of obtaining representative specimens, the same is not true of the impalpable virgin soils directly derived from widespread quaternary formations, as is extensively the case in the South and West. The soils of large tracts of country can thus be classified into a few typical ones and their intermixtures.

2. Series of analyses of representative specimens, made on a uniform plan and interpreted in connection with all local circumstances, and experience had in cultivation of similar soils, can furnish information of great practical value concerning the native fertility, treatment in cultivation, and modes of improvement. They serve—

a. To *identify* as well as to *distinguish* from one another the soils of different localities, rendering the experience had with them at other points applicable in the selection and cultivation of new lands.

b. To demonstrate a great abundance or extreme deficiency of important ingredients, showing *which* of necessity will require to be added in manures, and *which* may be developed by stimulants or by the fallow.

c. Inasmuch as in soils of similar origin the decomposition of the minerals may be presumed to have advanced to a similar extent, the amounts of nutritive soil ingredients extracted therefrom by the same solvent under identical circumstances will be more or less accurately the measure of their native fertility, and of their duration in the process of exhaustive cultivation. This presumption receives strong confirmation from the results of the analyses of Mississippi soils.

d. The same analyses show that, *cæteris paribus*, the thriftiness (*i.e.* immediate producing power) is sensibly proportional to the amount of *lime* present, while (again *cæteris paribus*) the duration under exhaustive cultivation is proportionately diminished. This is what might have been anticipated, but is a highly important practical intimation.

3. Finally, the author contends that the omission of such investigations from the work of geological surveys is a grave one, not justified either by the plea of their costliness or of their want of utility, and the more to be regretted, as within a few years it may be impossible to obtain representative specimens of the best soils in their virgin condition, and because such researches require a comprehensiveness of plan not to be attained save under the shadow of a public work. The agricultural colleges will have to take up again, under great disadvantages, the work thus neglected by the state surveys. The objections that have been raised against the utility of soil analyses would, if applied to other departments of research, have debarred us from some of the most

important discoveries, and are not of sufficient weight to justify us in giving up all hope of being able to understand and control the mode of action of the several kinds of soil. We assuredly can never hope to advance therein *without* analyses. He therefore calls upon the geologists of other states to rectify the omission before it is too late and a legislative *fiat* declares their labours to be "finished."

MOHAIR.

THE raising of mohair wool from Angora goats is now more than an experiment, several shipments having been made from California with favourable results. Difficulties have been encountered, owing to the ignorance of the habits of the animal and the laws which regulate its care and breeding, with a view to the cultivation in perfection of wool suitable for fine textile purposes, and of a quality which will remunerate the breeder. Asia Minor being the natural habitat of the Angora goat, hitherto the finest and most silky fleeces have been brought from that quarter; but successful attempts have been made at the Cape of Good Hope in the rearing, and it is believed, on good grounds, that some parts of California are better fitted for the production of a valuable mohair wool than either Asia Minor or the Cape. Capital, experience, and management will effect the rest. The chief points, an attention to which will bring about success, are a suitable locality having reference to the nature of the animal, and a vigilant care exercised in the maintaining of a pure thoroughbred stock. The last is of more consequence with regard to the Angora goat than perhaps to most animals, if the silky nature of the fleece is the object (the whole value nearly lies there), and, whatever may be the appearance of the animals, or the inviting exterior of crosses, this is the first and all-important consideration. A vast industry for America is in its infancy. No fabrics have taken a firmer hold, both here and abroad, than mohairs, with the prospect of an extension only limited by the high cost. And there are animals closely allied to the Angora goat whose fleece is almost as valuable, and in some instances more so, that could be successfully reared on the land sloping from the Andes to the Pacific, where every necessary variety of climate for the raising of this class of stock is to be found.—*New York Times.*

A GOOD EXAMPLE.

THE practical genius of the Germans—who only a few years ago were ridiculed as a nation of dreamers—is finding occupation in an attempt to resolve the difficulties of effective railway management. The railway department for the empire has prepared (according to the "Silesian Gazette") a set of new rules, to be shortly laid before the Federal Council, to regulate the conveyance of goods and other matters of interest to the commercial community. In order thoroughly to discuss the still more important question of the security of the lives and limbs of the travelling public, a conference was held last month in the rooms of the railway department of the Ministry of Commerce at Berlin. This conference was convoked by the Minister of Commerce to consider all the various questions connected with the safety of passengers. The co-operation of the directors of the various lines was invited, and a programme (drawn up in advance) shows the general character of the anticipated discussions. The programme embraces thirty-two separate questions, which are divided into four leading categories:—1. Works on the line and at the stations. Under this are included the construction of switches, the means of repairing them, and their maintenance and control. 2. Signal systems, with the view to increased security, particularly stoppage signals in the possible case of interruption of telegraphic communication. 3. Means of control. Here will be considered questions as to brakes, precautions to prevent waggons that are stationary from being moved by the wind, the control of the rate of speed, the nature of the goods waggons, and the avoidance of accidents in coupling carriages. 4. Management. Under this head will specially be considered how far the defective training of the officials is responsible for accidents, and what changes in their education might be adopted; how far the overworking of officials has contributed to accidents, and a number of similar points. The discussion of these subjects will probably suggest many others, and it is hoped practical benefits will result.—*Pall Mall Gazette.*

The American Engineer and Inventor:

SELECT ABSTRACTS OF PATENTS RECENTLY GRANTED IN THE UNITED STATES.

[*For information concerning this department see the notice on the wrapper below the Contents of the Number.*]

524. Improved Boiler Feeder.

The object of this invention is to furnish an automatic water feeder for steam boilers. There is a many-chambered cylinder, the periphery of which is provided with cogs, which engage with a perpetual screw of the driving shaft, by means of which the cylinder is slowly revolved. The cylinder is placed between two plates, which are secured together by bolts. The cylinder revolves watertight between these plates, the contact surfaces being ground so as to make tight joints, and still allow the cylinder to revolve. The feedwater descends through a pipe and fills one of the chambers, the air contained in the chamber being forced out through an upper pipe, in which the water rises to a level with that in the tank. Power being applied to the pulley on the worm shaft, the cylinder is slowly revolved, and the full chamber is carried round to the discharge pipe, while other chambers are filling and being moved in the same manner. When the chamber reaches the discharge pipe, the water is subjected to boiler pressure of steam by means of the steam pipe; and if there is a deficiency of water in the boiler, the water in the chamber will fall by its own gravity, and the chamber will move along filled with steam until it reaches orifices in the upper plate, when the steam will be discharged. The cylinder thus keeps revolving, and the chambers constantly discharge water in sufficient quantity to keep the water in the boiler up to the desired level.

525. Improved Water Wheel.

The gauges for regulating the capacity of the buckets according to the volume of water to be used consist of horizontal plates, constructed in the form of the cross section of the space between the upper or vertical portions of the buckets. They are attached to the lower end of the curb surrounding the upper portion of the wheel, and extend above it and the upper wall of the chutes as high as the gauges may require to be lowered. The gauges for the chutes are attached to the curb, which is the gate to be raised and lowered by it, and thus are adjusted as readily as the gate is. The gate being connected by its sleeve with the sleeve to which the wheel gauges are connected, both the wheel and the chute gauges will be adjusted together and alike, and at the same time that the gate is opened, so that the labour of adjusting the wheel gauges separately to the different heights as the stream varies, or as the labour to be performed by the wheel varies, will be avoided.

526. Improved Safety Platform for Railroad Car.

The invention is designed to prevent persons from falling between the platforms of cars and fracturing their limbs, or otherwise more seriously injuring themselves. It consists in a relative construction of the platform ends which enables them to come into contact, yet allows the lateral motion required in the attachment to each car of a projection which passes under the opposite one (and this prevents them from telescoping with one another), and finally in pendant stops, which are placed on the sides of platform and outside of the rail to prevent cars from readily upsetting and falling over embankments.

527. Improved Reversible Plough Point.

This invention relates to the plough iron now generally used in the cultivation of cotton upon a one-horse frame, and attached only to the foot of standard by a bolt, which passes through the plough, and which holds it in a notch upon an inclined surface. These are known through the South as twister ploughs, the share and mould board being in one piece, somewhat spirally concaved. The invention consists in the peculiar relative construction of the two parts of these twister plough irons, so that the mould-board and point become interchangeable, and, wearing at different parts, enable nearly or quite double the service to be obtained out of the same quantity of metal.

528. Improved Bee Hive.

The hive is so constructed that honey can be removed with perfect safety, yet without injury to the bees, and the swarm can be divided, or entirely removed from the hive, with equal facility. The hive is also well ventilated, is provided with means of protection against moths, and adapted for use of a ventilating attachment in the form of a wire gauze basket which allows admission and circulation of air, and forms practically an extension of the hive, which the bees may enter at any time whenever the heat is too great within the hive.

529. Improved Car Coupling.

The bumper heads are alike and made of the usual hopper shape. Pivoted within at its angle by a transverse pin, is a two-armed lever, one arm of which projects toward the mouth of the bumper, and has a hook on its extremity, and the other extends up through a slot in the upper part of the drawhead. The link, entering, is guided by a spring so as to catch under the hook. A cord may be attached to the forward end of the upper arm of the hooks and carried up to the top of the car, so that the hoop may be raised for uncoupling from that point.

530. Improved Plough.

This invention relates to ploughs, and consists in a projection plate applied to the rear of the mould-board, so as to serve several useful purposes; in a novel mode of splitting the beam so that the landside is formed out of the same piece of metal; also in placing the hook which connects the mould-board and beam at the rear end of an extension of the beam, and enabling it to hold by the rear end of the mould board.

531. Improved Artificial Teeth.

This invention has for its object to furnish artificial teeth, single and in blocks, so that they may be more conveniently and firmly secured to the various plates or bases upon which they are set or mounted. It consists in a platinum lining upon the back of the teeth, with or without pins. When the teeth are to be applied singly, or in blocks, to a rubber or vulcanite base or plate, the platinum lining will be covered up and concealed by said plate.

532. Improved Wood Fence.

The stakes are used in pairs, set in such an inclination toward each other that they intersect or cross, and are placed at the usual distance apart to form a panel or fence. A rider is supported in the angles formed by the intersection, and an upright is placed centrally between each pair of stakes. These uprights extend to near the intersection of the stakes, with a rider extending across the top ends thereof. Braces are attached to the stakes at one end, while the other end rests, beneath the lower angle of the latter, on the rider. The uprights are connected with the stakes by slats, and placed at an angle of fifteen degrees with the surface of the ground. Rails rest on these slats, and their ends lap past each other by placing them on opposite sides of the uprights. The fence is said to be straight, and proof against unruly stock as well as high winds.

533. Improved Grave Covering.

This invention relates to mounds erected over graves, and consists in three arches of stone sunk in the ground so that their upper faces are about level with the surface. On these rest four inwardly inclined plates, which support another plate with an oval opening and an angular recess.

534. Improved Device for Changing the Speed of Machinery.

This invention consists in a mechanical movement by which the velocity of a drive shaft may be quickly lessened to give greater power, or the reverse, a portion of the former being converted into the latter, or *vice versa*, as may be desired.

535. Improved Explosive Engine.

The object of this invention is to construct an engine which is driven by the explosive force of powder charges. The invention consists in the introduction and explosion of powder charges into chambers, which are alternately discharged to act on pistons, which turn the driving wheels, and are regulated by suitable mechanism. The base frame on which the engine is placed is of oblong shape, and contains two powder chambers arranged parallel to each other in longitudinal direction at both sides. The driving wheels produce, by alternately completing one half of a revolution on each wheel, rotary motion of a shaft from the reciprocating motion of the pistons. Each powder chamber is closed by an adjustable breech piece, which may be detached for cleaning out the chamber. The closely-fitting piston moves in the chamber, its piston-rod connecting, by a cross pin, with a strong spiral spring, which is also applied by cross head and pitman to the side of a driving wheel. The required quantity of powder is introduced, in cartridge form, into the chamber by means of a vertical casing, which is arranged on guide rails placed on the top of the chamber. A brush of casing serves to secure the cartridge in recess of the sliding piece, which is carried forward and backward in guide rails. On the forward motion of the slide the cartridge drops into a chamber, to be carried back toward the breech piece by the returning piston, and be discharged by the concussion against the breech block. The piston is, by the explosion, forced forward again, and causes, by its action on the pitman, the rotation of the wheel. The smoke and gases escape through side apertures, admitting the immediate re-charging of the chambers.

536. Improved Butter Print Press.

The object of this invention is to furnish to farmers and dairymen an improved butter print or press, by which the butter may be quickly and evenly formed into cakes of required weight, with suitable print marks thereon, without previous weighing. It consists in a sliding box, into which the butter is introduced and pressed on a printing block, by a follower block and lever, into suitable shape and weight.

537. Improved Painted Cloth Cover.

The cloth or other material used for ornamenting, is backed before painting on with any stiff material, whether of pasteboard, wood, metal, rubber, or any combination of the same, provided it is thick and strong enough to fasten permanently and securely thereon. It is cut of the exact size required, and bound with metallic edges to protect the edges and prevent a disconnection of the cloth from the board. The metal edges serve also as an ornamental finish. If used as a table cover it may be glued, tacked, or screwed down, or it may also be used as a movable cover, and be made with leather and cloth hinges to be folded up, which, in the case of chess-boards and other games, is very desirable.

538. Improved Armpit Shield.

The object of this invention is to provide means for protecting the dresses of ladies from the ruinous effects of perspiration under the arms; and it consists in a shield or protector made of what is known as chamois skin or equivalent material, and oiled silk or equivalent material in combination.

539. Improved Life-Preserving Mattress.

This invention is a life-preserving mattress, made of cork strips or similar buoyant material, having end sections connected with a middle section by straps that interlock, one sliding upon the other, and both together allowing the said end sections to turn up on either side of the middle one, so that they can swing up edgewise when the mattress sinks by the weight of a person. Cords are arranged on the edges of the middle and end sections for grasping the float by one floating in the water, and they are provided with the loops, also, for grasping hold of and for making temporary rowlocks, in which to use paddles for propelling the raft.

540. Improved Taper-Turning Attachment to Lathes.

This invention consists of a toothed rack on a lathe frame, and a system of gears on the tool slide, which moves lengthwise of the lathe, combined with the screw which works the tool slide crosswise in such manner that the tool is fed crosswise of the lathe at the same time that it is fed lengthwise, so as to turn tapers. The wheels are graduated and the supports contrived so that, by the use of interchangeable wheels of different sizes and numbers of teeth, tapers of various predetermined angles can be produced, and they can be turned either way—that is to say, from the large to the small end, or *vice versa*.

541. Improved Car Coupling.

The entering coupling bar passes back in such a direction as to strike the pivoted block below its pivoting point, swinging the same back and continuing on beneath its lower edge. An enlargement is formed in the upper part of the drawhead, to give room for the pivoted block to swing in. The coupling bar is made with a joint in its middle part, to adapt it for use in coupling cars of unequal height. This joint is made with almost straight shoulders, to guard it from dropping down too far. The ends of the coupling bar are rounded off, and have shoulders formed upon their upper sides near their ends, to receive the lower ends of the pivoted blocks, and thus sustain the draught strain. With this construction, the lower end of the block is free to swing inward, to allow the cars to be coupled by the entrance of the coupling bar. To uncouple the cars a key is drawn out, which allows the block to swing freely in either direction.

542. Improved Vehicle Axle Box.

This invention has for its object to diminish the wear and friction of axle journals and boxes, particularly those of rail car trucks; and it consists in a chambered axle box provided with a flange in which the lubricating material is contained, and from which it is discharged to the frictional surfaces, and on a perforated journal sleeve, which is also provided with discharge orifices by means of which the axle is lubricated. There is a cap nut on the end of the axle, which incloses the ends of the box and sleeve, and comes in contact with the hub of the wheel.

543. Improved Wheel for Vehicles.

The object of this invention is to construct an improved metallic wheel for waggons, carriages, &c. It consists of a hub with projecting central piece and two detachable collars, into which the two dovetailed ends of the spokes are mortised and held by lateral screw connections. The curved spokes bear against the tire, and are, with their conical outer ends, screwed therein.

544. Improved Railway Switch.

This invention consists of apparatus arranged in connection with the switch to be actuated by a shaft or wheel on the locomotive coming in contact with a lever alongside of the rail, and caused to unlock the switch and change it, and shift the target before the locomotive runs on to the switch, the said apparatus being arranged so that a locomotive approaching from either direction will shift it.

545. Improved Miner's Pick.

This invention consists in a movable bit attached to an ordinary pick, provided with two triangular points and prevented from turning by a clamp screw.

546. Automatic Lubricating Water and Gas Cock.

This invention consists in a water or gas cock provided with a valve having an oil reservoir in one or both ends and connected with the outer surface of the valve by a suitable aperture; also in a spring piston, applied in connection with the screw cap, so as to expel the oil.

547. Improved Children's Carriage.

The body is constructed mainly in the form of a covered chair with inclosed sides, and suspended by arms from a rod, which is mounted at the top standards, extending up from the lower portion of the frame about as high as the top of the body, so that it can be swung forward and back whenever it may be desired to do so to quiet the child. For this purpose the wheels are made small and arranged wide apart, to suspend the body as low as possible, and afford a substantial support for the body when swinging. It is proposed to mount the frame on the middle cross bar of the wheel frame by light, flat, semi-elliptical springs, bolted to said bar at the middle, and connected at the ends to the side pieces of the frame by their turned-up flanges, which are notched and fitted in notches in the frame.

548. Improved Sash Fasteners.

This invention relates to the ordinary sash fastener, which prevents the window from being opened, and consists in means whereby the introduction of a blade or instrument between the sashes, in order to unlock them, may be effectually prevented.

549. Improved Car Coupling.

The invention consists in the coupling bars, provided with V-shaped and inclined or dovetailed shoulders upon their upper and lower sides, and at different distances from their points, and jointed to the ends of the drawbars.

550. Improved Spike Bar.

Bars for drawing spikes on railroad tracks and in other places are very liable to be broken, and they fail first in the claws. The object in this invention is to provide a remedy; and it consists in making the claws in separate pieces, and attaching them to the bar, so that if either claw fails it may be renewed without trouble or delay.

551. Improved Land Roller.

Each roller is formed of wooden staves or sections, secured together by means of rods, which pass through them. Both ends of each of the rods pass through the section or stave, and are provided with screw nuts, which fit in recesses formed in the edges of the stave. A central transverse groove is formed in each stave, which adapts the cylinders to be applied to the wheels, and firmly secured thereto. When this is to be done the nuts are removed from the ends of the rods, and the staves separated from each other, so as to make the cylinders large enough to admit the wheel. When the latter have been adjusted in the grooves, the staves are again brought close together and clamped around the wheels by means of the rods and nuts. The wheels are mounted on an axle provided with a tongue forming a running gear, such as is ordinarily used as the front running gear of farm waggons.

552. Improved Eaves Trough Hanger.

The invention is an eaves trough hanger having a prolonged end, adjustable vertically in a clamp, and turned over to hold the trough at any elevation desired, thus avoiding the use of an adjusting screw.

553. Improved Machine for Cutting Cloth.

This invention consists of a movable cutting table or board on a stationary bed, a guide for the cutting knife, a pawl for moving the cutting-table, and an adjustable stop and a gauge for regulating the movement, all combined in a manner by which the cutting of cloth strips into sample pieces of any size required is simplified and facilitated. The extent of forward movement of the board and the cloth upon it is regulated for the required length of samples by a stop, against which the shoe of a pawl strikes, and by which it is arrested. A guide is then swung back down on the cloth, ready for guiding the knife for cutting off the sample, and a gauge shows where to fix the stop for samples of the length required.

554. Improved Ventilator and Pipe Hole Plate for Tents.

This invention consists of a metal plate, provided with an aperture of sufficient size to afford proper ventilation or allow the exit of a stove pipe, and which is fastened to the tent cloth, or to a suitable patch in the latter. A valve is arranged for closing the orifice, provided with springs and a cord and pulley.

555. Improved Belt Hole Cover.

The stationary part of the cover is made in two parts, which fit closely upon each other, and are secured together by bolts passing through the sides of the case. The bottom plates of said case are secured to the floor. The upright plates project upward at any desired angle, according to the direction of the belt, and are made in the form of segments of circles. Curved flanges are formed upon the lower part of the inner sides of the uprights, near their edges. The inner edges of these flanges correspond with and fit upon each other, where they are secured in place by projecting points, which interlock. The upper or movable part of the belt cover has a base plate, which is curved upon the arc of a circle, to fit and slide upon the arched flanges as a seat. In the middle part of the base plate is formed a hole of sufficient size for the belt to pass through freely, and which is surrounded by an inclined flange, making the opening hopper-shaped. By this construction the belt can carry the upper part of the cover with it in its lateral movements, and the said part will stand in any position into which it may be moved, preventing the belt from being rubbed and chafed.

556. Improved Toy Horn.

The mouthpiece is cast in two parts, in one of which is formed a little slot, in which the reed is inserted at one end, and wedged in so as to be held. The other piece is in the form of a conical tube, and fits on over the one in which the reed is fitted, and is secured by wedging. In the second place, the part having the reed is formed with a conical tubular portion on the end, to be attached to the body of the horn, and secured by forcing it on the conical end, so as to be held by friction. It may also be soldered if desired.

557. Improved Balance.

The object of this invention is to so produce, for the purposes of scientific investigation and the use of the public in general, an improved balance, which consists in arranging a spirit-level and adjustable weights with one end of a scale beam, carrying a weighing pan at its opposite end. All the weights, large and small, are put on the scale-pan, which will then balance the weight of the beam, so that the bubble of the level will come to the centre of the tube. If not, a loose nut is adjusted till the exact balance of the weights is obtained. The body to be weighed is then placed on the pan and the weights removed gradually until the bubble is again in the centre. The weights removed are equal to the weight of the body. The weights may also be taken off and added in the usual way till the beam is again horizontal. Those remaining give the weight of the body.

558. Improved Slide for Extension Table.

The object of this invention is to so improve the slides for extension tables that the splitting of the slide bars is prevented by transferring the strain to the centre instead of the sides, and allowing the construction of the slide bars in half the thickness of the slide bars in common use. The invention consists in arranging the ends of the slide bars with arched slide plates having short extensions, which are inclined toward the longitudinal axis, and slide in similarly inclined grooves of the adjacent slide bars.

559. Improved Car Starter.

A bevel wheel is attached to a sleeve, and revolves freely on the axle. On the back of this wheel is a clutch, with which a sliding clutch coupling engages and acts upon the axle when the spring is uncoiling. This spiral spring bears against the coupling, and forces it to engage with the clutch of the wheel. In winding up the spring, the teeth of the coupling clutch slip past each other without affecting the axle; but when the coil spring reacts they engage, and the power is conveyed to the axle. A frame is given a sliding motion beneath the bottom of the car by means of the lever, and is confined to the bottom of the car. A shaft is attached to this frame by journal boxes, and a bevel wheel on this shaft meshes with the clutch wheel, and another bevel wheel on the end of this shaft meshes with the wheel fast on the car axle. The coil spring is wound up around the shaft in stopping or braking up the car. One end of the spring is attached to the shaft, and the other end to the frame. In braking or stopping the car, the two mitre wheels are thrown into gear, which winds or coils up the spring and stops the car. Should the momentum of the car be greater than required for winding up the spring, a brake may be applied to the wheel by the driver.

When it is desired to start the car, the driver moves a lever to the other end of a stop-plate, which throws the bevel wheels out of gear. The clutch wheel, being engaged with the coupling and axle, receives the reactive force of the coil spring and transmits it to the axle, thus starting the car.

560. Improved Nut Lock.

This invention relates to that class of nut-locks which by some elastic substance take up the longitudinal expansion of the bolt, and provide at the same time for a corresponding contraction. It consists in placing rubber balls between a washer and the flanges of nut, and holding them together temporarily by upsetting an annular projecting lip of the one upon the opposite wall of the other.

561. Improved Machine for Forming Hat Frames.

A vertical shaft, pivoted to a cross bar of the frame, and its upper end revolving in bearings in the table, is rotated by a lever worked by the foot of the operator. To the upper end of the shaft is attached a circular table, to which is secured the lower form or mould. The upper form or mould, which is secured to a circular table, is rigidly attached to a short shaft which passes up through a hole in the cross bar, by which it may be raised. The cross-bar is connected with the foot lever, so that the operator can bring the upper mould down upon the lower mould to form the hat by pressing down the lever. The material from which the hat frames are formed, and which is wound upon a rod, is dampened by a suitable arrangement of water vessels and sponges.

562. Improved Combined Extension Measuring Rod and Divider.

The object of this invention is to facilitate the taking of measurements between rigid surfaces and striking circles, arcs of circles, and ovals and elliptics. In each of two opposite sides of the centre piece is a dovetail groove. Near the inner ends of the extension pieces are metallic dovetails, which fit into and slide in the dovetail grooves of the centre piece, and guide and hold those pieces to the centre piece. Bands are attached to the centre piece, which admit the extension pieces so that they may slide back and forth therein, and are held in any position by thumb screws. These extension pieces are graduated or marked off into inches and fractions, so that the length of the rod in feet and inches may be at any time readily ascertained. A removable point and pencil, each fastened in place by a thumb screw, are provided when the rod is used as a tram for striking circles, arcs of circles, ovals, or elliptics. In the latter case the third point is attached to the end of the centre piece. When not used as a tram, the points and pencil may be disposed of in the ends of the pieces.

563. Improved Blackboard.

This invention consists, mainly, in arranging the blackboard with hinged leaves in a strong standard or stock, in which it may be raised or lowered by rack and ratchet arrangement, to be inclined by hinged arm and bow construction, and folded open by pivoted levers.

564. Improved Extension Trunk.

This invention has for its object to furnish an improved trunk, which shall be so constructed that it may be extended to form a trunk of large size, or contracted to the size of an ordinary trunk. The sides and the end parts of the extension are made with an offset upon their outer and inner sides, the outer shoulder being designed to rest upon the upper edge of the sides and ends of the lower part of the trunk, so that the outer surfaces of the said parts may be flush with each other. The inner shoulders are designed to receive the till. The edges of the ends of the extension are rabbeted upon their inner sides to fit upon rabbeted single blocks, which have a metallic plate attached to their outer sides to overlap the outer surfaces of the ends. With this construction the hinges that connect the top part to the lower part of the trunk are so formed, that they can be readily attached to and detached from the upper part, or rear extension piece, as may be required. The hasp of the lock is made long, and should have two keepers attached to it, to enable the trunk to be locked when extended and when contracted.

565. Improved Grinding Mill.

There is a rectangular bed frame on which is an upright frame near one end, consisting of two "bents," on the bridge trees of which is a horizontal shaft carrying the running stone, which overhangs the bridge tree and runs in a case. In the upper part of the latter is a spout for the escape of hot air, and in the lower part is a spout for the escape of the meal. In front of the runner is a stationary stone, standing face to face with it, and is pivoted at its horizontal axis by trunnions, supported in the arms of a crotcheted standard, and said trunnions can be shifted forward and back to balance the stone. The arrangement forms a universal joint, on which the bed stone accommodates itself to the runner. The feed shoe, under the hopper, delivers the grain into the eye of the stationary stone, in which there is a projection of the shaft, with a coarse spiral screw thread, which conveys the grain to the runner, where it is met by the radiating distributing plates on the runner, which work it along between the stones and distribute it equally. The shoe is agitated by a tappet on the shaft. It will be seen that these mills can be geared by a direct belt from the driving shaft on the pulley upon the shaft in the most simple manner, and the spindle of the runner has not to support the weight of the stone on its end or step, but only the necessary pressure for grinding.

566. Improved Apparatus for Preserving and Forcing Beer.

This invention relates to an apparatus intended to preserve such fermented or other liquids which may be deteriorated, decomposed, or in any way injured by coming in contact with the atmospheric air, or by coming under a less pressure than they were originally subjected to, or by attaining an improper temperature during the time said liquids are on draught. The invention consists in means for excluding the atmospheric air and replacing the same by a gas, indifferent and not injurious to the liquid to be preserved, and bringing said gas under a sufficient pressure to preserve, increase, or diminish the temperature, and thus keep them in their normal condition.

567. Improved Railway Switch.

This invention relates to means whereby the liability of a railway train running off the track in consequence of the misplacement of a switch is avoided. It consists in a peculiar mode of combining a three rail switch and two pairs of frog rails.

568. Improved Apparatus for Transferring Embroidery Patterns.

The object of this invention is to facilitate the operation of transferring embroidered designs, patterns, &c., from a perforated original pattern sheet to other sheets of paper or other material. The apparatus for holding and giving tension to the pattern sheet consists of a frame and an adjustable clamp attached to one side of the table by hinges, so that it can be turned up to a vertical position. The adjustable clamp consists of a bed piece with a rib thereon and a hinged clamp, which has a groove which fits on the rib of the bed. The end of the sheet is laid on the bed over the rib, and then the clamp is turned down and fastened by means of the buttons. The clamp is now drawn back, so as to give the sheet the proper tension to hold it smooth and keep it in position. It is adjusted by means of cords, the ends of which are attached to the spiral springs, and the other ends are passed through the eyes. The tension is given by drawing the cords back. When the proper tension is given, the cords are secured around pins, and the clamp is fastened to the side pieces of the frame by the finger screws. By the ordinary process, this stamping, as it is called, through a perforated pattern, is done with coloured powder, and the pattern is held by the hand. A single pattern can only be used in this manner, on account of the difficulty in keeping it smooth. By the improvement a number of patterns may be contained on the sheet, and stamped at one operation. Instead of using a powder, a liquid is employed with which the brush is saturated. When the pattern sheet is properly stretched, the brush, which has been dipped in the liquid, is drawn over it, and the impression is made. The frame with the pattern sheet is then raised, and the impressed sheet is removed. The frame is again closed down, and the operation is repeated, and so on for any required period of time.

569. Improved Spring Bed.

This invention has for its object to improve the construction of spring beds in such a way that the bed will not crush down at the side, and that the bed will be level when two persons of unequal weight may be lying upon it. Ordinary coiled springs are interposed between, and the ends of which are attached to, the bottom and top straps. In the outer row of springs, upon both sides of the bed, every other spring is composed of two cups, made in the form of truncated cones, placed with their smaller ends adjacent to each other, and with a partition in the neck or smallest parts. Two springs are coiled into conical form, so as to fit into the cups or case, and have their smaller ends resting against the opposite sides of the partition of said case. The larger end of the lower spring is attached to the bottom straps, and the larger end of the upper spring is attached to the top straps. By this construction, any tendency to press the bed down or over at the side presses the sides of the springs against the sides of the case. This keeps the springs upright, so that the person upon each side of the bed will be supported by the springs of that side.

570. Improved Paper Hanger's Brush.

This invention relates to a novel construction of paper hangers' brushes whereby they may be made to place the paper in proper position upon the wall. It consists in applying a hinged spring-pressed clamp to the top of the brush, also in a novel mode of enabling the operator to open the clamp after the paper has been located upon the wall, by a lifter, connected by a cord or wire with his hand. It also consists in providing the lifter with an extension arm and subjecting this to the action of a crooked lever, which holds the clamp open until the brush is taken down from the wall.

571. Improved Cigarette Machine.

In using this machine, the tobacco is placed in a receiver above a distributing apparatus, which causes a gauged quantity of tobacco required for a cigarette to drop down to a compressor beneath, by the compressing action of which the tobacco, being rolled up, is inserted afterwards into a paper tube ready to receive it, by means of a peculiar device. The paper sheets are laid into a rectangular box of the like section to the surface of the cigarette paper. A piston is constantly acting on the heap of sheets, and compels them to lean against a plate, which is called "a hand," forming one end of the box, and intended to catch them one by one, and carry them to the rolling-rod, whereby the same are formed into tubes. The paper sheet is rolled up within a cylindrical tube or mould, split through one of its generating lines, which split one edge of said sheet, enters, and is caught by the rolling rod, that is set rotating within the said mould. The lower end of the rolled up sheet is, together with the mould, carried up to the compressor containing a roll of tobacco, which is then, by another rod, driven into the paper tube. The mould moves anew and presents the rolled sheet containing its tobacco, and having its lower end folded up, to the action of the upper end folders, when the cigarette is completed, and the mould returned to its starting point, or under the rolling rod. On its entering the mould, the rod drives out the made cigarette, and gets hold of a new sheet, which undergoes the very same operations as the foregoing one. From what has been said, the making of a cigarette consists of three different operations, effected simultaneously with three different moulds, so as to obtain a threefold speedy manufacturing action. The first operation consists in taking a sheet, rolling it, and folding the lower end thereof. The second operation consists in introducing the tobacco into the paper tube thus formed, and the third and last operation consists in folding the upper end.

572. Improved Spring for Chairs.

This invention has for its object to furnish an improved spring for use upon articles of furniture, which shall be readily adjusted to give it any desired tension. The invention consists in an improved spring, formed by the combination with each other of the two rubber blocks, between which is placed the middle part of a U-shaped bar. Another U-shaped bar is passed between the arms of the bar above mentioned, and thus passes around both the rubber blocks. A yoke passes along the upper side of the upper block, and the various parts of the spring are connected and held in place by two bolts which pass through the yoke through notches in the ends of the rubber blocks and through the middle part of the U bar. By this construction, by tightening and loosening the nuts of the bolts, the tension of the spring may be regulated as required. Suitable construction adapts the spring for use in connecting a chair seat to its pedestal.

573. Improved Harrow.

This invention consists of a couple of pulverizing bars in front, four, more or less, bars with knives or teeth behind them, and a wide pulverizing bar behind the toothed bars, all connected together a few inches apart by chains, to be drawn sidewise over the surface. The toothed bars are arranged obliquely to each other to give a side draught to the teeth or cutters, to some extent. The knives incline from the front backward so as to rise upon the clods, etc., and cut them by pressing downward ; but they can be made to point forward and downward to be used like a coulter by reversing the bars.

574. Improved Means for Propelling Vessels.

This invention relates to improvements in the class of propellers formed of oscillating paddles ; and it consists chiefly in the arrangement of the upper pivot for the slotted stems of the paddles to shift forward or backward of the vertical plane of the crank, so as to hold the paddles in such manner that they dip vertically into the water and thus save the loss of power due to beating it obliquely.

575. Improved Governor for Steam Engines.

This invention consists more particularly in the use of an oscillating ring or plate, or of a combination of several parts, which are more or less symmetrically placed around a common centre support and gravity. This plate or ring is kept in continuous oscillation, so that any point on a line drawn from the centre of gravity, at right angles with the plane of this plate or ring, will describe a circle in space. Various applications are made of this principle, the following of which appears to be the simplest. The disc is mounted by a universal joint upon a hollow support, through which a shaft carrying the three arms and buttons is fitted, a spring crowding said pins against the plate and serving as equivalent for a weight. A pinion hung loose upon the shaft meshes into a toothed segment that is mounted upon a weighted crank lever from which the connecting rod extends to the valve. When the speed of the engine is increased, the increased friction on the buttons causes the loose pinions to act upon a lever in such manner as to move it to more or less shut the valve.

576. Improved Trimmings.

This inventor has patented three inventions of similar nature. The first consists of a trimming for dresses and other articles of wearing apparel for ladies, composed of a strip of muslin, lace, silk, or any other suitable textile fabric, with cross plaits arranged in groups of, say, four or five (more or less) plaits in a group, and plain portions between the plaits of about the same width as the groups thereof. The second invention consists of a reverse box-plaited and puffed trimming for dresses, etc., in which, by reason of the plaits of one side being midway between those of the other side, they have the form of an ordinary box plait at one margin of the trimming, separated into two members at the other margin, and merged into the two adjacent box plaits thereat. The machine which is used for making this trimming consists of a pair of plaiting rollers with puffing teeth or formers in one, and sockets or dies in the other, and four plaiting blades for plaiting the cloth and pressing the plaits between the rollers. The third invention consists of a reverse side plaited trimming in which the plaits are folded in opposite directions at the margins, and, when desired, a puff is formed between the plaits at the edge. To make this trimming a pair of intermittingly rotating rollers is used, with puffing cogs or teeth, when the trimming is to be puffed, combined with a pair of folding blades or knives and a feeding guide.

577. Improved Car Coupling.

A coupling hook is pivoted in the drawhead, so that it turns freely on a pivot rod. The long limb of this hook forms the coupling pin, and when the car is uncoupled is in nearly a horizontal position. When the cars come together, the end of the link strikes the centre of the hook, which throws the long limb to an upright position.

Before reaching this position, its end strikes the underside of a hinged cover and raises it so as to pass a shoulder. The cover drops by its own gravity, and confines the hook, so that the shoulder forms the abutment against which the link pulls. To uncouple the cars, the cover is raised by means of a chain. A forked weight bar is pivoted at its rear end, and its weight is brought to bear upon the short limb of the hook, by means of pins, to keep the hook and bar steady and in position before coupling, or when the hook is turned down. The forks of this bar also drop upon the end of the link, and hold the link in a horizontal position, so that it is unnecessary to go between the cars to guide the link when coupling the cars together.

578. Improved Milk Cooler.

A water chamber is arranged on a frame by covering it with a layer of sheet metal, painted on both sides to resist the action of the water thereof. The water course is produced by longitudinal partitions, which connect by apertures at alternate ends, so that the water is compelled to take a circuitous course through said chamber. The cold water passes around the partitions, and is conducted off through an exit pipe. Another sheet of metal, painted on both sides, is placed on top of the water chamber, and attached to the main frame. The milk pan is placed on the cover, being cooled as readily as by being directly in contact with the water, zinc especially keeping the water cooler, and preventing the corosion of the bottom of the milk pan. The milk pans are thereby kept dry, and last a great deal longer than when placed directly on the water. The top cover forms also a table, which allows the use of smaller pans, according to the quantity of milk obtained, keeping also butter and other articles cool, as they may be set thereon in any vessel.

579. Improved Automatic Hatchway Guard.

This invention consists of a gate arranged to slide up and down in the posts or doorway of the elevator, and connected by cords running over guide pulleys with a tilting lever. The latter is moved by a pin on the upper end of the elevator carriage, and caused to raise the gate out of the way when the carriage comes up to the place for unloading and loading. When, by the passage of the carriage to a higher floor, the gate is allowed to fall, the descent is regulated by a pin on the lower end of the carriage, which passes above the lower end of the lever just before the upper pin escapes from the upper end. If the carriage descends without the upper pin passing above the lever, said pin regulates the descent. The gates closed below the carriage are opened by the lower pin on the carriage, and their closing is regulated by the upper pin.

580. Improved Curling Iron.

The object of this invention is to produce an improved curling iron, which is adapted to be conveniently used on every gas or other flame, keeping its polish and surface uninjured, and perfectly clean for use, and being easily handled with one hand, while the other curls the hair on the iron and manipulates it in the proper manner. This invention consists of a hollow metal tube, with a double elbowed handle applied to its larger conical base, which is provided with air channels for carrying up the flame to the full length of the iron, and also with diametrical side recesses having vertical openings, by which the extinguishment of the flame on the burner is prevented.

581. Improved Box Clamp for Tobacco Presses.

This invention consists of a clamp formed of two blocks, made of hard wood, notched across the grain upon their inner sides, and held together by two or more bolts. The ends of the blocks at their inner edges are rabbeted to form grooves to receive the screw posts. To the outer forward corner of the upper side of the rear part are secured plates, and suitable arrangements are provided so that the rear part will not be pushed back out of place while the clamp is being manipulated. The straps are arranged to prevent the parts from being worn by the heads of the bolts.

582. Improved Foot Warmer and Improved Artificial Stem for Cut Flowers.

This invention is an improvement in the class of portable heaters consisting of a metal case containing a block of soapstone or other material, which is removed when required to be heated. The invention consists in an arrangement of ribs and pins for supporting the block and holding it in place on the cover of the case. The pins prevent the block moving about in the box when the latter is being handled, and the ribs keep it from coming in contact with the cover, and thus unduly heating the same, thereby causing injury to the floor. The same inventor has also devised an artificial stem for cut flowers. It is the present practice of florists to stem flowers by attaching them to wooden splints by means of wire or thread. The improved device is formed of a wire shaped spirally into the form of a hollow inverted cone, which is provided with a shank. To attach the device to a flower, the stem is drawn down through the coil until the latter embraces the base of the calyx, when the cone is compressed by slight pressure between the thumb and finger.

583. Improved Wheel Plough.

This invention has for its object to improve the construction of the wheel plough for which letters patent No. 138,329 were granted April 29, 1873. The invention relates to an arrangement of a rocking bar and pivoted rod in connection with the tongue and beam of the machine, for the purpose of adjusting them at certain angles to each other. By this construction the chain braces, in drawing the sulky, tend to press the forward end of the plough beam downward, and thus cause the plough to run deeper in the ground.

584. Improved Cutting Attachment for Sewing Machines.

The object of this invention is to furnish an improved cutter attachment for sewing machines, by which fabrics of all kinds may be cut simultaneously with the stitching, and at suitable distances from the line of stitches, by the action of the machine. The instrument may, with slight variation, be attached to nearly every sewing machine, and consists of two upright arms, one of which is attached to the guide casing of the needle bar, and the other is connected loosely with the main arm of the sewing machine. The stationary arm carries at its lower end a cutter blade, which, together with a pivoted cutter blade operated by the reciprocating arm, cuts the fabric as the same is fed by the machine to it and the needle.

585. Improved Propulsion of Vessels.

This improvement consists in propelling vessels by the alternate action of steam pressure and a vacuum, respectively operating and formed in a cylinder having a single orifice which is in communication with the water wherein the vessel floats, whereby the quantity of water in the cylinder is expelled, and the same or an equivalent quantity re-admitted in continuous succession through the aforesaid orifice. Thus no supplementary tube or passage is required to supply the steam and vacuum cylinder with the water to be expelled, but the inflow and outflow occur at the same point. The invention further consists in a valve and float mechanism connected with the cylinder, whereby the admission of steam is automatically regulated, as the water is expelled and admitted, thereby securing a proper and efficient action, and allowing the steam pressure to be constantly applied.

586. Improved Automatic Lubricator for Car Axle Journal.

This invention consists in a method of automatically supplying the hot journals of a car axle with lubricating material by interposing, between the journal and a superposed lubricant-holding chamber, plugs fusible below that degree of temperature which will generate combustion.

587. Improved Implement for Capping Cartridges.

The object of this invention is to provide a convenient little instrument for capping the brass and paper shells used in the Parker and other breech-loading shot guns, by which the operation can be performed in a quick, neat, and perfect manner. It consists of a tubular spring clamp, which takes hold of the caps and transfers them to the countersunk base of the shell by striking sharply the knob of a bolt with spiral spring sliding in the clamp.

588. Improved Accordion, &c.

This invention consists essentially of the application of two "unisono" tuned reeds to every key of both key-boards of a wind instrument in which the key-boards form the sides of the bellows, as in an accordion, whereby one reed will sound by expanding and the other by contracting the bellows, and thus give the same note continuously as long as may be required. The invention also consists of sliding holders, in combination with the key-board of such instruments, by which the bellows can be worked by the wrists of the player, thus leaving all the fingers free to work the keys, and allowing the hands to slide along the key-boards, the instrument being supported at one end on the knees. The instrument thus improved is called an "acolodicon."

589. Improved Slide Valve Mechanism.

The main slide valve has end tubes that slide upon closely fitting guide rods. These guide rods have rear flanges that hold them movably between guide brackets. When the friction between the valve and its seat creates wear, the valve is thus enabled to lower itself and automatically take up the wear. A clapping and disagreeable noise is prevented by the use of an auxiliary valve, peculiarly constructed, and arranged in the steam chest and over the main valve. This valve has two subjacent cavities which alternately connect with the exhaust by a vertical passage, and are separated by a partition. The steam passes through ports into and out of the tubes, to alternately force the main valve in opposite directions, and recesses, over which pass the ends of the valve, to admit steam into chambers and thence to the tubes. The object of this arrangement is to cut off the egress of steam from these cylinders in time to form a cushion to prevent their percussive impact upon the rods. In order to render the valve self-adjusting, to take up its own wear, and also to drop according to the wear that takes place on the main valve below it, an auxiliary valve is provided, which becomes automatically adjustable by its own gravity, both as respects its own wear and that of the main valve.

590. Improved Link Guide for Car Couplings.

The bumper heads of the cars are constructed in the ordinary manner, except that their cavities are deepened, and have blocks inserted in them. The blocks have stems formed upon their inner ends which enter holes in the inner parts of the bumpers, and around which are coiled the springs by which the blocks are held forward. Upon the forward end of the blocks are formed flanges to support the pin when withdrawn. A curved frame, upon the inner sides of the side bars of which are formed grooves, receives the side bars of an inner frame. The rear end of the curved frame is hinged to the rear part of the bumper head, and its forward part is supported by a yoke, the side bars of which pass through guides attached to the bumper head. The frame can be raised and lowered, according to the height of the adjacent car, by simply turning a screw. To the outer end of the inner sliding frame is attached a plate which, as the said frame is drawn outward, comes into such a position as to support the link in a horizontal position. A weight and cord of sufficient size are arranged to draw the frame forward as soon as released. The weight is supported by a small coiled spring, arranged to relieve the jar when the cars are run together and the weight is drawn upward. The sliding frame is held when pushed inward by a lever pawl pivoted to the frame and held to its place by a spring. The forward end of the lever pawl projects at the side of the bumper, so that it can be readily operated to release the frame and allow it to be drawn forward by the weight.

591. Improved Toy Blocks for Object Teaching.

This invention relates to apparatus designed to facilitate the study of geometry, in the formation of geometrical figures, and to familiarize the minds of both the young and old with such figures, and also to afford recreation and amusement; and it consists in two triangular-shaped blocks, made of any material and of any size, by the use of which (and no other) various figures are formed by laying them together.

592. Improved Standard for Stools, Tables, &c.

The invention consists in an improved stand adapted to support different articles of furniture. The supporting stand consists of four curved legs, of which one is firmly connected to the central shaft. The other legs are hinged sidewise to each other, so as to fold nearly parallel to the stationary leg, and they are arranged to close accurately around the shaft. They are also provided with recesses around the shaft, and projecting lugs at their outer top ends. These lugs enter recesses of a round support which rests on the legs and binds them strongly together. A central circular aperture of the support, together with the recesses around the shaft, allow the insertion of the sockets of the different parts which are to be connected to this supporting stand. A hook of the outer folding leg closes into an eye at the lower side of the support, and prevents thereby the lifting off or otherwise disconnecting of the same.

593. Improved Plough.

The standard bars are set into recesses of the beam, pivoted to it by a strong cross bolt, and are connected rigidly at their lower ends so as to form a strong, rounded-off support for the under side of the ploughshare. A curved brace is rigidly attached to these bars, passing up between them and through a recess of the beam, above which it is provided with perforations and locked, according to the angle of inclination under which the ploughshare is set. An adjusting rod passes between standard bars along the rear of the brace and up through the beam, and is raised or lowered by a crank. Different shares may, in this manner, be attached to the plough, as necessitated by the various requirements of farming, and their angles of elevation and depression be determined by simply adjusting the fore end of the brace.

594. Improved Slide Valve.

The valve is truncated and wedge-shaped. The walls between which it is arranged constitute a double seat with double induction ports and exhaust. The steam enters ports at the ends of the valve, which moves far enough to open them in that way. At the lower edge the valve rests on a flat seat, and at the top it may or may not be provided with flanges to bear on the top of the seat. It is fitted on these parts so that it just wedges into the cavity between the seats steam tight. Channels are in the corners of the valve at the lower edges, and in the corners of the seat at the top, to admit steam as a check, which prevents the leaking of the valve to some extent. Such channels can also be employed to limit or balance the down pressure. It is believed that the pressure on the top will be governed by the area of the cross section of the ports at the line, and it can be reduced to the requisite amount for keeping the valve steam-tight by such channels, admitting the steam under it. The double seats afford greater length of ports with a valve and cylinder of a given size than can be had with the ordinary arrangement. The double ports will unite in one passage in any suitable way.

595. Improved Packages of Powder Charges for Blasting.

This invention consists in packing the powder, in convenient quantities, in long tubes of paper or any fabric or material of sufficient strength, rendered waterproof if necessary, of a proper shape and size to be used as a cartridge, and of such a length in excess of the powder inside as shall allow of its being folded into a compact form, and divided for use into cartridges of any desired length or weight. Each cartridge tube or package may be easily marked with the size, and quantity, and brand of its contents; and when it comes to the consumer, he can measure off from either end the quantity desired for a blast, slide the powder away from this point, divide the tube, fold back the ends, and the cartridge is ready for use, proceeding in the same way until the whole package has been used. Thus the danger of preparing the cartridge over the open keg and the liability to damage of the exposed powder are avoided, and the time and labour of making the cartridge, as well as the materials of which it is composed, are saved.

596. Improved Mould for Fancy Buttons.

This invention has for its object to furnish an improved fancy button, the mould of which shall be so formed that the cover may be put on, held in place, and ornamented with cord or thread without sewing. The invention consists in the grooves formed in the outer surface of the moulds, and in cords or threads in combination with the grooves of the moulds, for securing the cover in place upon said moulds.

597. Improved Drill for Well Boring.

The drill is made tubular and somewhat flaring, so as to cut a hole a little larger than its body. The lower edge is serrated so as to cut a ring groove into the stratum through which it is boring, the core or central part of the cut passing up through the cavity of the drill. The upper end is rabbeted, and on it is screwed the lower end of a tube, in the sides of which are formed a number of holes to allow the water to flow out, and thus lessen the weight. In the upper end of the tube is screwed a section of pipe, and other sections may be added as the hole increases in depth. To the upper end of the drill is hinged a valve, opening upward into the tube, so as, when the drill is raised, to carry the contents of the tube and pipe with it. With this drill, it is stated, a hole may be sunk by hand to the depth of two hundred feet, and with a lever to any desired depth. This drill also enables the operator to know exactly the kind and depth of strata through which a hole is being sunk.

598. Improved End Gate for Waggons.

This invention is an improvement in devices for securing end boards or gates of waggon boxes, and consists, chiefly, in a lever pivoted to the gate by a link or bar, and having at one end claws or hooks for taking into notches in one of the side boards, and at the other end a slot to receive a staple which projects from the gate.

599. Improved Soap Cutting Machine.

The object of this invention is to furnish to soap factories and dealers in soap an improved machine for cutting the soap blocks into pieces of any required size. The invention consists of a feeding frame provided with adjustable block carriers for forcing the soap against a suitable cutting frame, on which the cutting wires are rigidly applied by a stretching device, which consists of a supporting piece which carries a crank shaft. The wire is wound upon the shaft by turning it with a small crank, and retained in stretched position by a ratchet and pawl.

600. Improved Churn Dasher.

This invention consists in an improved form of churn dasher formed of bars crossing each other, which are made V-shaped with V grooves in their under side.

601. Improved Scrubbing Brush.

This invention is designed to furnish a scrubbing brush which contains a reservoir to hold water, soapsuds, or other cleansing liquid. This reservoir is in the brush back, in which a small air hole is made, the closing of which by the finger, while the brush is in use, will stop the flow of the liquid; or the hole may be provided with a valve. The improvement may be applied to blacking brushes, for which it is especially suitable.

602. Improved Grain Separator.

This invention is an improved grain separator, so constructed as to thoroughly separate the grain from the straw as they come from the thrasher, clean the grain and remove it, and carry the straw out of the machine and deposit it upon the stack. The frame of the machine is rectangular in form, and is encased upon its top and sides. The frame is from twelve to fourteen feet long, about four and a half feet high, and from three to four and a half feet wide. Two shafts revolve in a side bar, and to each are attached two wheels, which work in circular spaces in the casing of the machine, so that the straw and grain cannot escape. The wheels are connected near the rims, at their upper and lower parts, by two rods, the points of attachment of which form an angle with each other of one hundred and sixty degrees. The upper rods connect with the separating rack, the slats of which are provided with teeth, inclining forward, so that as the rack moves upward and forward it may carry the straw with it and may slide beneath the straw as it moves downward and rearward. By this construction, as the shafts are rocked, the rack receives the vertical and horizontal movements necessary to properly separate the grain from the straw and carry the straw forward. To the lower rods is attached the conductor which receives the grain from the rack and conducts it to the sieves. To the forward end of the conductor are attached fingers to break up the sheet of grain as it falls to the shoe or sieves. The conductor has the same vertical and horizontal movement as the rack. By suitable mechanism, the horizontal and vertical movements of the rack and conductor may be regulated at will. This adjustment enables the forward movement of the straw to be accelerated or retarded, as required.

603. Improved Corn Planter.

The seed-dropping mechanism consists of a slide which moves in guide slots of the hopper, at the bottom of the same. The slide is arranged with a band spring, to which is connected a lug which is acted upon by knobs attached to the spokes of the wheels, according to the distance at which the corn is to be planted. The knobs carry the spring and slide forward, and drop the seed inside of plough to the ground. As soon as the spring is released, the slide closes the hopper till actuated again by a knob. Cross pieces are attached to the circumference of wheels diametrically opposite to the knobs, for the purpose of marking the exact place at which the corn has been dropped. The driver is thereby enabled to see at any time whether he is planting in rows or not. As soon as he finds himself not exactly in line, he can, by placing his foot on the lever, raise the front wheels on the pivots, and regulate the planting by simply turning the wheels forward or backward, which allows him to plant as straight one way as the other. The broad concave hind wheels are placed back of the ploughs, and serve to cover the corn dropped in the furrows. By means of a lever which is operated by the foot of the driver, the pivoted frame with the wheels is raised, and thereby the planting interrupted at will, as required, by turning the planter or moving from place to place.

604. Improved Reciprocating Engine.

The piston rod extends through both cylinder heads, and discs fit thereon, one each side of the piston, and work air-tight in the cylinder. On the upper side of the latter are induction ports for the air, and valves for opening and closing them, which are connected by a valve rod. Short rods project into either end of the cylinder, by which the levers are thrown to work the valves, by means of the discs, which strike the rods when forced against the cylinder heads. The steam ports are on the lower side, as is also an injection port for water, to condense the steam after having thrown the shuttle to expel the air through the clack valves and shift the air valves. Supposing the engine to be standing with its piston at its forward end, and the valve shifted to admit steam at the front port, the real disc will thereby be driven to the other end of the cylinder, expelling the air; and just before arriving at the piston head, it will strike the short rod at that end, and close the right hand air port, and open the left-hand port; at the same time, if the injecting port be opened and water admitted, the steam will be condensed and a vacuum formed, so that the air admitted will drive the piston and other disc over to the right, with all the force due to the difference of the pressures on the two sides of the piston, which, in practice, will probably be about twelve or thirteen pounds to the square inch. At the same time the injection port should be closed to shut off the water; then if steam be admitted between the rear disc and the piston, it will be driven back to the left, expelling the air and water at that end, and taking their place to form a vacuum again by being condensed by water admitted; so that, as soon as the rear disc arrives at the end of its movement and strikes the rod, the air would be admitted behind the piston, and drive it back to the place of beginning, and so on.

605. Improved Safety Valve.

A short vertical pipe rises up from the top of the steam chamber, having a considerable enlargement near the upper end, which is bored out cylindrically, and, at a suitable distance above the bottom, perforated with numerous holes. The safety valve proper is seated at the top of the small bore of the pipe, and is provided with a cylindrical attachment fitted to the bore, as nearly steam-tight as it can be, and works up and down a short distance without friction. After the steam has lifted the valve, it cannot escape until the attachment rises as high as the lateral holes. By this means the lifting of the valve high enough to insure the opening of the escape to the full capacity of the bore will be caused.

606. Improved Wood Moulding.

This invention consists in a wooden or other moulding, provided with stamped ornamental figures or signs in intaglio, having the sides of the recesses bevelled and inwardly inclined, to facilitate the operation of gilding.

607. Improved Wheel for Vehicles.

An octagonal tube has a screw thread cut upon each end, and is lined at each end with anti-friction metal, to form the bearings for the axle. The two hubs have octagonal holes formed through their centres, to fit and slide upon the tube; and in their outer sides are formed dovetailed recesses to receive the dovetailed inner ends of the spokes, which are kept in place by plates bolted to the hubs. The inner part of the plates is rabbeted to receive the flange formed upon nuts, which hold the hubs and plates in place, and also move said hubs and plates out and in. The corresponding spokes from the two hubs meet at their middle parts, and their outer parts are connected together. The outer ends of the spokes have tenons, which enter holes in a rim, which is made convex upon its inner side and concave upon its outer side, which construction prevents the wheel from slipping. By this construction the spokes are shortened by spreading their inner forked ends apart by turning the nuts outward. This shortens the spokes and loosens the rim. By turning the nuts inward, the inner ends of the forked spokes will be moved toward each other, the spokes will be lengthened, and the rim tightened.

608. Improved Car Coupling.

This invention consists of a pair of spring jaws, side by side, with heads or enlargements near the front end between which a double-headed coupler enters. The latter is secured by the heads of the jaws engaging it behind its enlargement, the jaws being confined against springing open by a forked locking key, which drops down with one of its prongs on each side. The forked locking device is raised and lowered by a handled elbow lever; and a catch is combined with said lever, to engage it just after it has raised the locking device, and hold it up until the cars are to be coupled again. This catch is so coupled with one of the spring coupling jaws that, when it is swung back by the lever to allow it to pass beyond said catch, the latter is caused to withdraw the said coupling jaw, to allow the coupler to escape freely and uncouple the cars. A spring is combined with the elbow lever of the locking device, to insure the return of the latter to confine the coupling jaws when the elbow lever is released by the spring catch.

609. Improved Overalls.

The object of this invention is to furnish overalls readily applied without the use of buttons, suspenders, &c., fitting the body of the person, and self-adjusting to the position of the same. It consists of short elastic bands, inserted and applied into the band piece of the overalls, and closed by a common belt buckle, which is drawn through a slit of a flap attached to the lower front edge of the overalls, and covered by the same.

610. Improved Apparatus for Puddling Iron.

On the rod or shaft of the puddling tool is a pulley for revolving it. The pulley is fitted by a journal at one end in a bearing in a standard, and the shaft is fitted in the pulley so as to slide freely endwise, and has a long key or spline working in a groove in the pulley, to be revolved at the same time. The standard is jointed to a section which is seated by a collar on the bench, and has a cylindrical extension passing down through a long slot in the bench top, which is secured by a pin. The bench ranges parallel with the front of the furnace, and is pivoted just above the ground, so as to swing toward and from the furnace. The handle portion of the puddling tool rod does not revolve with it when held by the attendant for directing the tool. It will be seen that the tool can be moved in and out by sliding in the pulley in which it is supported; also, by swinging the bench forward and backward on the pivots, that it can be swung horizontally on the bench by turning the section of the support, and that it can be shifted along the bench parallel with the furnace, and thus all necessary movements can be made to work the tool in all parts of the furnace to manipulate the iron for puddling and balling.

611. Improved Portable Stove.

This invention relates particularly to the arrangement of a damper and apertured horizontal diaphragm in an upper chamber of the stove, whereby the course of the heat and products of combustion is controlled with reference to their effect on a culinary vessel set into said chamber. A small vertical rectangular case is mounted on short legs and contains a fire pot, flue, oven, and chamber. The fire pot extends downward a little below the bottom of the other portion of the stove, and has a perforated bottom and sides. The combustion chamber extends up through the oven space at one side, and discharges into the heating chamber, and a door opens into it for supplying the fuel. On the side of the stove opposite to the fuel door is the oven door. The boiling and stewing vessels are made long enough to extend through the heating chamber into the oven, through the top, to utilize the heat of the oven for boiling, stewing, &c. A plate is arranged in the chamber, parallel to the top of the oven, dividing it horizontally into two parts. Immediately over the combustion chamber said plate has an opening which can be partially closed by a sliding damper. By adjusting the damper, a large share of the products of combustion will be diverted to pass beneath and around the end of the plate before reaching the flue, while the remaining portion will pass vertically into the same through the openings on each side of the damper.

612. Improved Tomb.

This invention has reference to a tomb or grave cover which is composed of a base or pedestal of masonry, upon which is placed a slab of artificial stone resembling marble, formed by moulding upon said base a composition of hydraulic cement, sand, and water, or their equivalents.

613. Improved Horse Power.

This invention relates to railway horse powers: and it consists of cog-wheels on the drums over which the endless chain travels, gearing with large multiplying wheels, one on each side of the chain. Between these wheels is a drum on the same shaft, on which the chain rests, so as to be carried in returning to the upper side; and the multiplying wheels are geared with a countershaft having pinions and transmitting pulleys, from which the motion is taken by belts. The frame supporting the endless chain rests by the wheels of its drums on the large multiplying wheels, and can be shifted so as to ascend from either side to run the machine in either direction, and to change the inclination for varying the speed. The drums of the endless chain are weighted to prevent them from jumping out of gear with the multiplying wheels.

614. Improved Apparatus for Filling Cans with Tomatoes, etc.

There is an inclined tube, tapering or funnel-shaped, at its lower end, which terminates in a small pipe. An adjustable can-holder is placed in front of the end of the tube, and provided with a movable cut-off plate. In the tube is a piston, connected with a counterpoise. The tomatoes being placed in the receptacle through a suitably arranged hopper, the piston being caused to descend by pressing a treadle, forces the contents out of the tube and into the can. When the latter is full, the cut-off plate is placed so that its opening no longer corresponds with the end of the tube, so that its solid portion prevents the escape of the tomatoes after the can is removed. A trough is placed in such a position as to receive any of the substance being canned that may escape from the tube, or may be spilled while filling the cans, and conduct it to a receptacle placed at the rear of the machine.

615. Attaching Stereotype Plates to Blocks.

A stereotype plate is cast on and around a wooden block or blocks, and thus attached thereto so that, when an impression is taken, it can be "locked up" without the delay and preliminary labour required to attach the ordinary stereotype plates to blocks or backing. The invention is important to printers, especially to proprietors of country journals and others who use selected matter, also to advertisers in general.